UAV
TACTICAL CONTROL SYSTEM
(TCS)

Tactical Control System

TCS

JPO • UAV

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Joint
Concept of Operations
(CONOPS)

VERSION 1.0

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APPENDICES.

FIGURES

1.0 EXECUTIVE SUMMARY

The Executive Summary will be prepared after review and approval of Version 1.0 by the Joint Warfighter Planning Group (JWPG) Service component and Service headquarters representatives.

The Executive Summary will be a two page maximum synopsis of Sections 2 through 5 of the CONOPS. It will be written for the Joint Force Commander and echelons above the JFC to provide a broad view of TCS and the optimum employment of TCS in joint warfighting.

2.0 STATEMENT OF PURPOSE. The Tactical Control System (TCS) is an acquisition category (ACAT) II program that provides military warfighters with a scaleable command, control, and communications, and imagery/data dissemination capability for the family of Tactical Unmanned Aerial Vehicles (UAVs) and the Medium Altitude Endurance (MAE) UAV (e.g., RQ-1A Predator). TCS is also capable of receiving and disseminating imagery/data from High Altitude Endurance (HAE) UAVs. Because TCS is Defense Information Infrastructure/Common Operating Environment (DII/COE) compliant and scaleable, its capability is tailorable to the user.

This concept of operations (CONOPS) provides a single source reference that broadly describes TCS system capabilities and limitations and also serves as a general "how to" TCS document. It provides an operational framework and general guidance for the employment and operation of TCS. The information herein is meant to be sufficient to assist tactical commanders in deciding when, where, and how to employ TCS, and how to realize the maximum tactical benefit from the unique capabilities TCS brings to the battlespace.

This CONOPS describes the operational concepts that will be utilized by U.S. Atlantic Command (USACOM) and USACOM Service components to employ TCS in joint or Service training/exercises, demonstrations, and tests, and to use TCS in actual operations in the USACOM AOR. Individual Service component commanders are encouraged to develop complementary TCS CONOPS documents with more definitive TCS employment guidance for their forces. Likewise, theater Commanders-in-Chief (CINCs) may use this CONOPS as the framework for developing TCS CONOPS specific to their area of responsibility (AOR) and operational situation.

This is a "living" document and will be updated to reflect lessons learned from the employment of TCS in exercises, demonstrations, and tests, and in actual joint and Service operations. Changes to TCS-related joint and Service doctrine, and modifications or upgrades to TCS hardware and software will be reflected in updates to this document. Until TCS reaches full operational capability (FOC), this CONOPS will be reviewed semi-annually as needed. After FOC, CONOPS review will be conducted annually. The review process is the responsibility of the Joint Warfighter Planning Group (JWPG), sponsored by the TCS Program Manager, Program Executive Officer for Cruise Missiles and UAVs (PEO-CU), and chaired by Commander-in-Chief, U.S. Atlantic Command (USCINCACOM). Principal membership in the JWPG is accorded to USACOM Service components; supporting membership includes the Services and other organizations within the operating forces; contributing membership includes TCS/UAV/command, control, communications, computers, and intelligence (C4I) subject matter experts.

This document provides the TCS user with a basic description of the TCS system, capabilities and limitations, general employment concepts and operating guidelines, specific examples of potential applications of TCS, and a broad understanding of TCS-related employment considerations and issues. The information and concepts presented are current with the tested and demonstrated capabilities of the TCS system. The CONOPS itself is unclassified, although the TCS system can operate at any level of classification required for the operations being supported.

SECTION 3. TACTICAL CONTROL SYSTEM (TCS) DESCRIPTION

3.1 PURPOSE. This section provides a brief history of TCS, describes system capabilities, the five levels of TCS interaction, system components and TCS configurations, interoperable functionality with the various families of UAVs and the myriad C4I systems, and summarizes system operation and limitations.

3.2 PROGRAM HISTORY. Realizing the advantages of a system with truly joint interoperability and commonality, Congress directed the Department of Defense (DOD) to consolidate UAV programs in 1988. DOD's initial attempts to comply with Congressional direction focused on achieving hardware commonality through the use of a downsized short range UAV ground station and by establishing software interoperability standards through the use of Joint Integration Interfaces (JII).

In January 1990, the Joint Requirements Oversight Council (JROC) approved Mission Need Statements (MNSs) for both a Close Range Reconnaissance, Surveillance, and Target Acquisition (RSTA) capability and a Long Endurance RSTA capability. These MNSs established the need to interface UAVs with selected standard DOD command, control, and intelligence systems, architectures and protocols, both current and planned. The subsequent advent of the MAE and HAE UAV programs highlighted the operational value of integrating air vehicle control and product distribution into an interoperable and scaleable system with established standards and protocols. Fully integrating UAVs into the existing and planned future battleforce structure required interoperability to be the prime consideration.

Existing software and UAV data links were not compatible or interoperable. The ground control stations had neither the required capabilities nor the capacity for architectural growth to satisfy all joint operational requirements. To be compatible with new or improved warfighting systems, every new software or hardware configuration required the development of new software to interface with each type of UAV control station. <u>There were no non-materiel alternative solutions that would establish standard software architecture for UAVs.</u>

To overcome this shortfall, in February 1997, the JROC codified the requirement for a UAV TCS to provide common ground reception, processing and control, and to be fully interoperable with MAE UAVs, tactical UAVs (TUAVs), and future TUAVs and collection systems. This Joint Operational Requirements Document (JORD) also specified the requirement for TCS to fully exploit Predator capability at all levels and to be capable of receiving HAE payload information. The TCS program was developed to design a system and implement the standards and protocols that will make current and future air vehicles interoperable with existing hardware, software and ground stations.

TCS program development progresses from threshold (initial) to objective (final) capabilities in three phases. Program specifics are described in more detail in Appendix A.

3.3 TCS SYSTEM CAPABILITIES. TCS is a software-focused program that provides the warfighter with a scaleable and modular capability to operate UAVs on existing computer systems and interface with current and future C4I systems to disseminate UAV sensor products. Scaleable capability refers to TCS system design that provides five levels of interaction ranging from receipt and transmission of secondary imagery and data to full control and operation of a UAV to include takeoff and landing. Modularity refers to the use of common hardware and the ability to increase or decrease capability by adding or removing system components, cards, or chips. Scaleability and modularity allow TCS to be configured and downscaled to meet the user's needs and deployment or operational constraints. TCS capabilities are primarily provided through software, software-related hardware, and extra ground support equipment (antenna, cabling, etc.) necessary for the control of the current family of TUAV (Outrider and Pioneer), MAE (Predator), and future tactical UAVs. In addition, TCS will have the objective capability of receiving HAE UAV payload information.

TCS software operates on current Service hardware: TAC-X (Navy), CHS-II/SPARC 20 (Army/Marine Corps), and SGI/DEC (Air Force). For Navy, TCS will be the control system for UAV operations from ships and submarines. For Army and Marine Corps, TCS will be an integral part of the high mobility multi-wheeled vehicle (HMMWV)-based TUAV ground control station (GCS) and the Tactical Operations Center (TOC) at various echelons of command. Air Force TCS will be a modification of MAE UAV GCSs.

System capabilities enable TCS operators to:

- Control and monitor multiple air vehicles simultaneously
- Format, send, and receive tactical communications messages
- Control and monitor multiple UAV payloads simultaneously
- View and exploit payload data from multiple payloads simultaneously
- Send and receive analog video and NITF digital imagery
- Send and retrieve payload data
- Plan UAV missions
- Send and receive voice communications
- Monitor the health and status of the TCS system

TCS software is developed for open architectures and provides UAV operators the necessary tools for computer related communications mission tasking, route flight planning, mission execution, and data processing. The software provides high resolution, computer generated, video graphics that enable operators trained on one UAV system to control different types of UAVs or UAV payloads with appropriate formal training. TCS core software is Global Command and Control System (GCCS) compliant, non-proprietary, and the architectural standard for future UAVs.

TCS provides a common Human Computer Interface (HCI) for tactical airborne platforms to simplify user operations, training, and facilitate seamless integration into the Services' Joint C4I infrastructure across all levels of interaction.

3.4 TCS LEVELS OF INTERACTION. TCS is interoperable with different types of UAVs and UAV payloads across five levels of interaction. Although the standard TCS configuration includes two workstations, the scaleable and modular nature of TCS permits full functionality at all levels of interaction to be accomplished with a single TCS workstation.

The levels of interaction are:

Level	Capability
Level 1	Receipt and transmission of secondary imagery or data.
Level 2	Receipt of imagery or data directly from the UAV.
Level 3	Control of the UAV payload.
Level 4	Control of the UAV, less takeoff and landing.
Level 5	Full function and control of the UAV to include takeoff and landing.

Each level of TCS capability incorporates the functionality of all lower levels. For example, Level 5 TCS, in addition to UAV launch and recovery, also provides the operator full capability to control the air vehicle in flight, control payload operations, receive UAV products directly from the air vehicle, and to disseminate these products to other TCS-equipped units. Figure 3-1 provides the five levels of interaction and the functional capabilities that can be accomplished at each level.

LEVEL OF INTERACTION / FUNCTIONALITY	
Level	**Functionality**

SENSOR DATA RECEIPT/TRANSMISSION
 	
1. INDIRECT PATH (via MCE, C4I SYSTEM or TCS)
2. DIRECT PATH (UAV to USER)
	• OPERATIONAL COORDINATION
	• RECEIVE & PROCESS SENSOR DATA
	  • ANALOG (RS-170)
	  • DIGITAL (NITF, OTHER)
	• DISPLAY SENSOR DATA
	  • OVERLAY ON GEO (MAP) DISPLAY
	  • ANNOTATE (VALUE ADDED)
	• TRANSMIT SELECTED DATA VIA COMMS SYSTEMS (SECONDARY DISSEMINATION

3. SENSOR CONTROL & DATA RECEIPT/USE	• LEVEL 1 & 2 FUNCTIONALITY • DIRECT CONTROL OF SENSOR PAYLOAD • VIA LOS LINK OR SATELLITE LINK
4. SENSOR & AIR VEHICLE CONTROL & DATA RECEIPT/USE	• LEVEL 3 FUNCTIONALITY • MISSION REPLANNING • AIR VEHICLE ROUTE PLANNING (WAYPOINTS, PRE-DEFINED PATTERNS) • AIR VEHICLE FLIGHT CONTROL
5. FULL UAV CONTROL - LAUNCH & RECOVERY	• LEVEL 4 FUNCTIONALITY • MISSION PLANNING • MISSION MONITORING • LAUNCH, RECOVERY, & LANDING

Figure 3-1. Level of Interaction/Functionality

3.4.1 Level 1. TCS Level 1 interaction is the receipt of UAV-derived imagery and data through existing communications architectures without direct interaction with the UAV. Level 1 can also include the subsequent dissemination of received imagery and data. Level 1 requires a TCS workstation and connectivity to an existing information dissemination network. UAV product (imagery or data) can be received and disseminated through any C4I system with which TCS can interface. Level 1 TCS operations require minimal TCS-specific training, and personnel totally dedicated to the operation of TCS are not required.

3.4.2 Level 2. TCS Level 2 interaction is the receipt of imagery and data directly from the air vehicle without filtering or processing at another echelon. It requires a TCS workstation component and additional hardware not required for Level 1 operations. TCS Level 2 requires air vehicle specific data link control modules (DCMs) and ground data terminals (GDTs) or an integrated data link terminal (IDT), and the correct antenna (line-of-sight [LOS] or beyond line-of-sight [BLOS] satellite communications [SATCOM]) configuration to receive imagery direct from the UAV. Training requirements are more robust than for Level 1.

3.4.3 Level 3. TCS Level 3 provides control of the UAV payload separate from control of the air vehicle. In Level 3 operations, the actual flight of the air vehicle can be accomplished from one control node while the payload is controlled from another. Since legacy UAV systems are equipped with a single air vehicle data terminal (ADT) providing only one up-link data signal, payload control from a control node other than the air vehicle control node is not possible. Two up-link signals are required, one for air vehicle control and one for payload control to allow for simultaneous command up-link from two different, geographically separated control nodes. TCS Level 3 operations have the same hardware requirements as Level 2. Level 3 payload control requires additional operator training and operators current in air vehicle payload control operations.

3.4.4 Level 4. TCS Level 4 provides functionality to control the air vehicle. Level 4 operations have the same hardware requirements as Level 2 and 3. Level 4 functionality is enabled through the activation of air vehicle control applications in the TCS software. Level 4 also requires the TCS system to have air vehicle control hardware (e.g., joystick, pedals, throttle, and touch screen) to provide both manual and automated control for air vehicles to be controlled. Manual air vehicle controls are not UAV specific, but can be dynamically reconfigured with software. Level 4 operations require significant operator training in the flight of specific air vehicles. In addition, air vehicle pilots must be current for the air vehicle(s) to be controlled.

3.4.5 Level 5. TCS Level 5 operations involve the full function and control of the UAV to include take-off and landing. Level 5 operations have the same hardware requirements as Levels 2-4 with the additional requirement of either a UAV Common Automated Recovery system (UCARS) or microwave based launch and recovery system.

3.5 TCS COMPONENTS. The TCS system is functionally and physically partitioned into hardware and software components to provide an open architecture that allows for efficient fault isolation. This architecture ensures:

- TCS is compliant with the Joint Technical Architecture (JTA) and the Common Imagery Ground/Surface System (CIG/SS).

- TCS utilizes DII/COE to the maximum extent practical.

- Commonality of TCS hardware and software utilized to support different payloads.

- The amount of hardware and software considered UAV flight critical is minimized.

- The effect of UAV modifications on the system is minimized.

- The effect of payload modifications and upgrades on the system is minimized.

- The effort to integrate the control of additional air vehicle and payload types is minimized.

- The impact of C4I system upgrades and modifications on the system is minimized.

- Commonality between TCS configurations is maximized.

3.5.1 TCS System/Subsystem. The TCS system consists of the following subsystems: antenna, data link, DCMs, launch and recovery, real time processor (RTP), synthetic aperture radar (SAR), workstation (non-real time processor), imagery, communications, and power distribution. Figure 3-2 shows the subsystems and elements within each subsystem that comprises the TCS system.
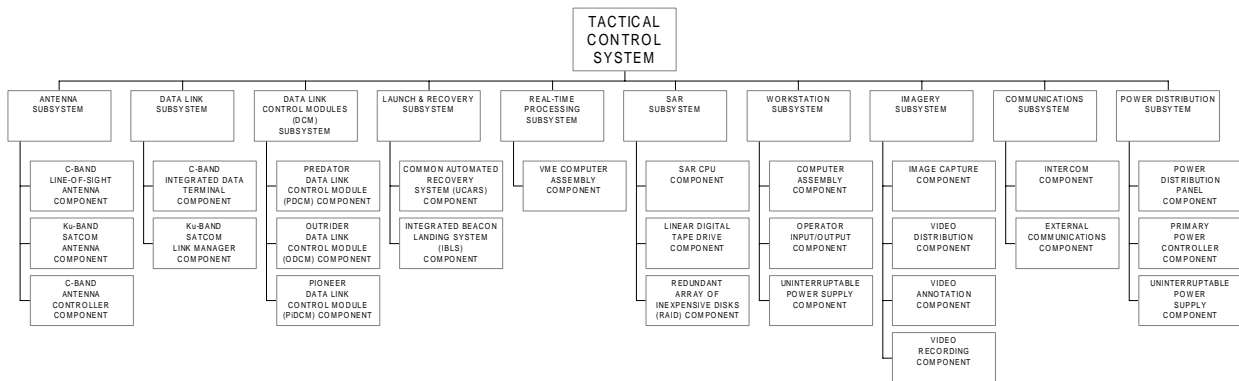
Figure 3-2. TCS System/Subsystems

The TCS system/subsystems are comprised of a variety of hardware and software components that are interfaced through hardware-to-hardware, software-to-software, and software-to-hardware interfaces to achieve TCS functionality. Figure 3-3 shows the component architecture of the TCS system.
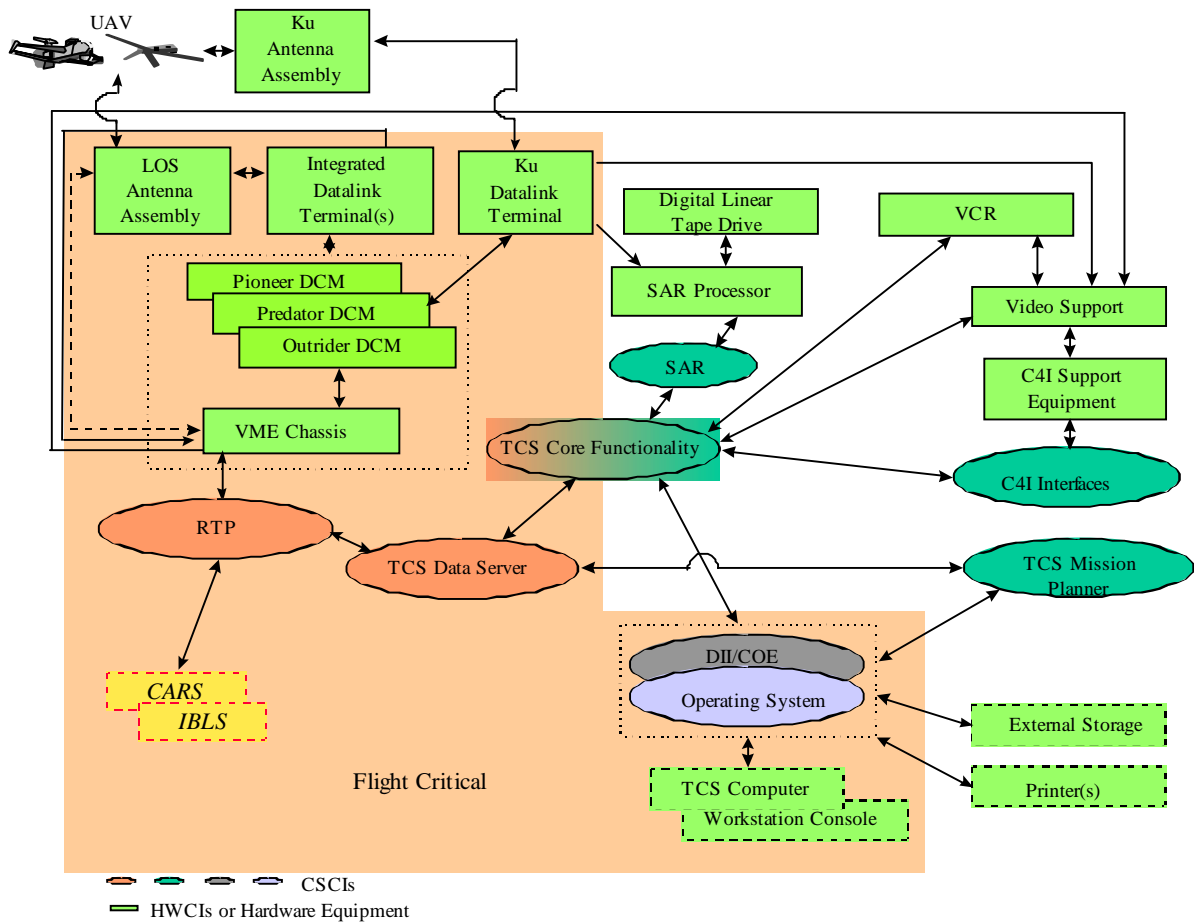
Figure 3-3. TCS Component Architecture

3.5.2 Hardware Components. The TCS system includes the following hardware components:

TCS computer. The TCS computer provides the central processing unit (CPU) to perform all the required functionality. The TCS computer consists of the hardware and the external and internal interfaces necessary to accomplish the real time processing of data.

Data Link Control Modules (DCMs). DCMs provide the functionality to perform real-time processing in order to maintain closed-loop communication and control of the air vehicle and to control ground-based data link components and communications with TCS components. The DCM translates specific air vehicle proprietary information into data sets that TCS can use. Each air vehicle specific DCM is built in accordance with the TCS air vehicle standard interface (AVSI) to facilitate rapid exchange of air vehicle information between the GDT and TCS.

DCMs are identified according to the air vehicle type: Predator DCM (PDCM); Outrider DCM (ODCM); and Pioneer DCM (PiDCM). Individual DCMs and their corresponding GDT can be replaced by a single IDT, which enables information exchange with all air vehicles.

Printer(s). Printers provide the functionality to print hard copy digital imagery, C4I messages, mission plans, and fault detection/location information.

Antenna assembly. The antenna assembly allows TCS to communicate with UAVs. Current legacy UAV systems utilize two types of antennae to transmit/receive signals with the air vehicle. These include a C-band LOS antenna and a Ku-band SATCOM antenna for beyond line-of-sight (BLOS) operations. The C-band antenna can receive air vehicle electro-optical (EO)/infrared (IR) imagery, air vehicle telemetry, and data. The Ku-band SATCOM can receive EO/IR and SAR imagery, air vehicle telemetry and data. Currently, only Predator MAE is equipped with a Ku band SATCOM and SAR capability.

Versa Module Eurocard (VME) computer assembly. The VME provides real time processing capability.

SAR processor. The SAR processor provides front end processing of raw SAR data including telemetry.

Linear digital tape drive. The linear digital tape drive records raw SAR data.

Redundant Array of Inexpensive Disks (RAID). RAID provides a buffer storage device for approximately ten minutes of SAR data.

Video cassette recorder (VCR). The VCR records and playbacks analog video and payload data.

Video support. Video support hardware receives, amplifies, converts, annotates, displays, and distributes analog video and captures freeze frames and stores, retrieves, and displays the freeze frames.

Power distribution. Power distribution components consist of hardware to condition and provide the appropriate power to the various TCS components. The system consists of:

> Uninterruptable power supply (UPS). UPS provides on line conditioned 115Vac power to TCS components, and upon loss of input power, a battery powered protected power source.

Power distribution unit (PDU). The PDU provides power distribution, management, and communications between UPS and TCS component loads.

Power distribution hardware. The power distribution hardware accepts primary power and provides the necessary interfaces to UPS for the various TCS components.

Workstation console. The workstation console provides the necessary operator controls, including manual controls (joystick, throttle, pedals, and touch screen) to input information into the TCS computer, and output displays to perceive TCS computer information. Workstation consoles are commonly configured within each specific TCS configuration. A notional TCS system consists of two workstations that are totally redundant.

3.5.3 Software Components. The TCS system includes software components as described below. Software is structured around a concept that allows an operator to accomplish an activity or set of activities through the organization of executable applications into 'roles' that enable or restrict functionality and determine which hardware components are required for that functionality.

DII/COE operating system. The DII/COE operating system provides information management and imagery exploitation and NITF file generation.

TCS core functionality. TCS core functionality software provides the following:

- System setup – provides for system setup and configuration.
- TCS main –provides general startup, dynamic loading, execution and termination of software.
- Air vehicle control – provides ability to upload route plan to the AV, enter flight commands, and executes emergency operations commands.
- Air vehicle flight monitoring – provides AV status data, data link status data, and graphical display of AV icon, flight route, payload swath, and GDT
- Data link control – enables operator commands for control of the data link and displaying the position of the data link platform.
- Payload control – provides coarse and fine control of payloads (currently only EO/IR payload control is provided).
- EO/IR imagery viewer – provides display of EO/IR payload video and status data and NITF image capture.
- EO/IR imagery data acquisition – displays NITF images with header and support data elements, allows operator annotation of images, and enables operator designation of targets.

- Tactical data and messages – enables generation of track/target data, and tactical messages for output to C4I systems.
- Launch and recovery – provides additional functionality to the AV control software to enable UAV launch and recovery.
- Training – provides user help and stand-alone training aids.

TCS data server. The TCS data server provides the interfaces with all other software components to support information flow. The data server provides the capability to share programs running on a distributed system, provides a mechanism to transfer data in a machine independent manner, and serves as a central repository for data moving through the system.

TCS mission planner. The TCS mission planner provides route planner, payload planner, data link planner, communications planner, plan monitoring, training, and maintenance capability. Mission planner functionality is enabled through access to a variety of data and databases that provide critical mission planning information (i.e., footprint, winds, threat, terrain, etc.)

Real Time Processor (RTP). The RTP provides antenna control, AVSI conversion, UCARS conversion, Integrated Beacon Landing System (IBLS) conversion.

Synthetic Aperture Radar (SAR). SAR software consists of the SAR payload control, imagery viewer, imagery data acquisition, and NITF files.

User interface manager (UIM). The UIM is responsible for all HCI displays (e.g., operator entry screen, heads-up display (HUD), etc.).

C4I interfaces. C4I interfaces enable TCS to receive air vehicle mission plans from service mission planning systems, transmit to Service mission planning systems, enter DII/COE compliant networks, and manage all aspects of the C4I system interfaces.

3.5.4 Support Components. The TCS system includes the following hardware support components:

C4I support equipment hardware. C4I support equipment hardware supports the interface with military and satellite communications equipment. Protocols supported include Transmission Control Protocol (TCP), Internet Protocol (IP), Simple Mail Transfer Protocol (SMTP), File Transfer Protocol (FTP), Network File Server (NFS), and X.25.

C4I communications equipment hardware. C4I communications equipment hardware provides communications through Mobile Subscriber Equipment (MSE)

and single channel ground and airborne radio system (SINCGARS) to transmit and receive messages and imagery.

Intercom equipment hardware. Intercom hardware provides verbal communications among multiple operators.

External storage hardware. External storage hardware provides additional storage space and the ability to store and retrieve mission plans, flight plan routes, communications plans, maps, C4I messages, digital images, NITF files, activities log, and training.

Data Link terminal hardware. Data link terminal hardware provides the data interface between TCS and air vehicles.

Several data links have been developed to satisfy specific needs. To achieve either integration or interoperability the data link transmitter and receiving elements must be compatible. There are three types of data links to consider: SATCOM; point-to-point directional LOS; and broadcast or omni-directional. Under North Atlantic Treaty Organization (NATO) Project 35 the United Kingdom is developing a NATO standard broadcast data link. TCS will be NATO Broadcast-Data Link capable. Commercial SATCOM links will be required to provide acceptable bandwidth for BLOS operations.

UCARS hardware. UCARS provides a microwave Ku band radar track system to track and control the recovery of UAVs that are UCARS capable. UCARS capability exists in the Outrider TUAV.

IBLS hardware. IBLS provides a differential global positioning system (GPS) launch and recovery system to track and control IBLS capable UAVs. IBLS capability exists in …………….

3.6 SYSTEM OPERATION. TCS consists of a set of core functions that are the central nervous system of the TCS architectural design. These core functions are common to all UAVs and required for fundamental operations. The core functions include mission planning, mission monitoring, data link monitoring and operator computer interface. TCS is segregated into two principal segments: real time and near real-time. The real-time segment includes those interfaces and processes critical to command and control of the air vehicle and data link. The non-real-time interfaces include mission planning and message handling functions. A key feature of the system design is the TCS AVSI that provides the real-time gateway between the DCM and the non-real time portions of TCS. This feature allows each UAV manufacturer to retain its proprietary air vehicle unique commands and system controls while enabling operations on the TCS network with core functions.

Each air vehicle requires its own unique datalink and antenna assembly. Therefore it is necessary to configure TCS with multiple GDTs and antennas, or a single Integrated Data Terminal (IDT) to control different types of air vehicles (Outrider, Predator, Pioneer). Specific GDTs or an IDT are required to synchronize the ground station signal with that of the ADT. This will remain a requirement until the advent of the tactical common datalink (TCDL) which will allow a single wide band antenna to transmit and receive multiple UAV signals.

The TCS system operates primarily by internally and externally interfacing hardware and software to achieve the functionality of a specific configuration.

> **3.6.1 Interfaces.** TCS has both internal and external interfaces that are necessary for the proper operation of the system. Internal interfaces support interaction between the various hardware and software components of the system/subsystems. External interfaces involve inputs and outputs between the TCS system and supporting equipment.
>
> TCS has the following internal interfaces:
>
> - Software-to-software:
>
>   - DII/COE to TCS core functionality, C4I interfaces, and the mission planner.
>   - TCS data server to TCS core functionality and mission planner.
>   - TCS core functionality to C4I interfaces.
>
> - Software-to-hardware:
>
>   - DII/COE to internal printer, external printer, and external storage.
>   - Operating system to TCS computer.
>   - C4I interfaces to C4I support equipment.
>   - TCS core functionality to video support, VCR, and SAR processor.
>   - TCS data server to DCMs (through AVSI).
>   - RTP to UCARS and IBLS.
>
> - Hardware-to-hardware:
>
>   - TCS computer to C4I support equipment, printer, video support, VCR, SAR processor, VME computer assembly, collocated TCS computers, external data storage, operator output, and operator input.
>   - VME computer assembly to DCMs, LOS antenna assembly, Ku data link terminal, integrated data terminal (IDT), and video support.
>   - Video support to VCR.
>   - DCMs to IDT and Ku antenna assembly.
>   - IDT to LOS antenna assembly.
>   - Ku data link terminal to SAR processor and Ku antenna assembly.

- SAR processor to linear digital tape drive.

TCS has the following external interfaces:

- C4I Interfaces. TCS C4I interfaces are shown in Section 3.8.2.

- Power Interfaces:

  - UPS to power distribution, TCS computer, and DCMs

- Imagery Interfaces:

  - TCS computer to Image Product Library (IPL) and DDE

- Launch and Recovery Interfaces:

  - VME computer to UCARS and IBLS

The TCS system has three states of operation: start-up, operations, and shutdown. Within the operations state, TCS has three modes of operation: Normal Operations Mode, Training Operations Mode, and Maintenance Operations Mode.

3.6.2 Normal Operations Mode. In the Normal Operations Mode, all system software is capable of operating concurrently to support operations at all five levels of TCS functionality. Access to this mode is controlled by DII login/user accounts. User accounts support flight and control of an AV or its payload, monitoring or processing of UAV data, or system configuration and setup.

In this mode, TCS supports the functions as shown in Figure 3-4.
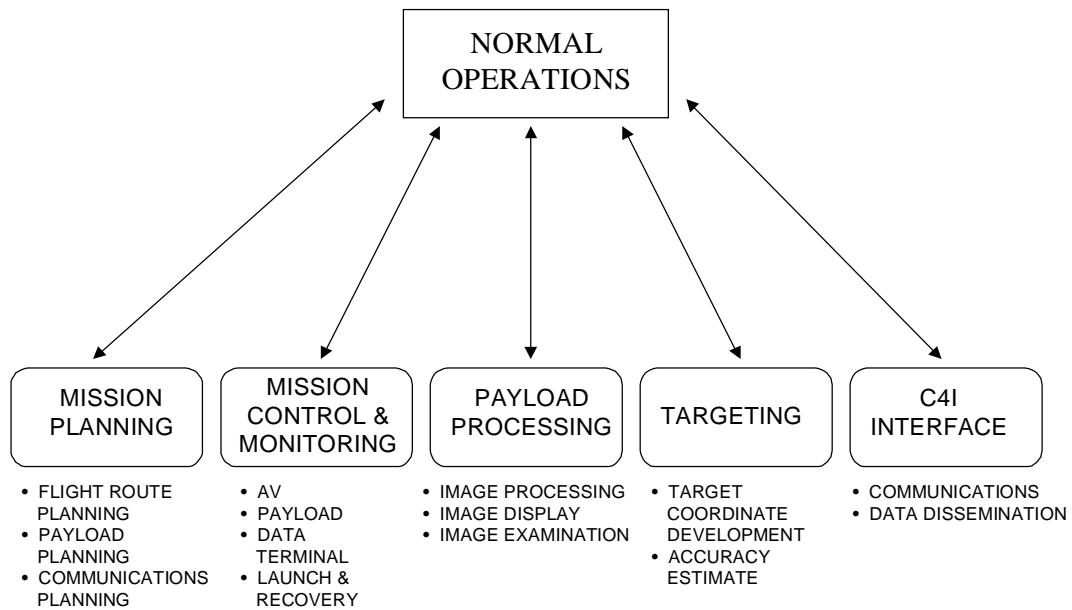
Figure 3-4. Normal Operations Mode Functions

All of these functions can operate concurrently without precluding or excluding any other functions.

Specific activities that enable the above functions include:

Receipt and transmission of C4I communications
Receipt and transfer of air vehicle control
Receipt and transfer of payload control
Launch and recovery of an air vehicle
Air vehicle control
Payload monitoring
Payload control
Payload data reception, utilization, and storage
Targeting
Data link monitoring and control
Mission planning
VCR control
Printer control
Input/output of voice communications
TCS to TCS communications
Input/output of analog video

3.6.3 Training Operations Mode. The Training Operations Mode provides the capability to train at any level of TCS functionality regardless of actual hardware

configuration. Access to this mode is controlled by the designation of training missions. In this mode, the following software operates: TCS core functionality, mission planner, C4I interfaces, DII/COE, operating system, and data server. All of these functions can operate concurrently without precluding or excluding any other functions. Figure 3-5 shows the Training Operations Mode functions.

```
                    ┌──────────────────┐
                    │    TRAINING      │
                    │   OPERATIONS     │
                    └──────────────────┘
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MISSION PLANNING	MISSION CONTROL & MONITORING	PAYLOAD PROCESSING	TARGETING	C4I INTERFACE
• FLIGHT ROUTE PLANNING • PAYLOAD PLANNING • COMMUNICATIONS PLANNING	• AV • PAYLOAD • DATA TERMINAL • LAUNCH & RECOVERY	• IMAGE PROCESSING • IMAGE DISPLAY • IMAGE EXAMINATION	• TARGET COORDINATE DEVELOPMENT • ACCURACY ESTIMATE	• COMMUNICATIONS • DATA DISSEMINATION

Figure 3-5. Training Operations Mode Functions

3.6.4 Maintenance Operations Mode. In the Maintenance Operations Mode, TCS core functionality software supports the functions as shown in Figure 3-6.

Figure 3-6. Maintenance Operations Mode Functions

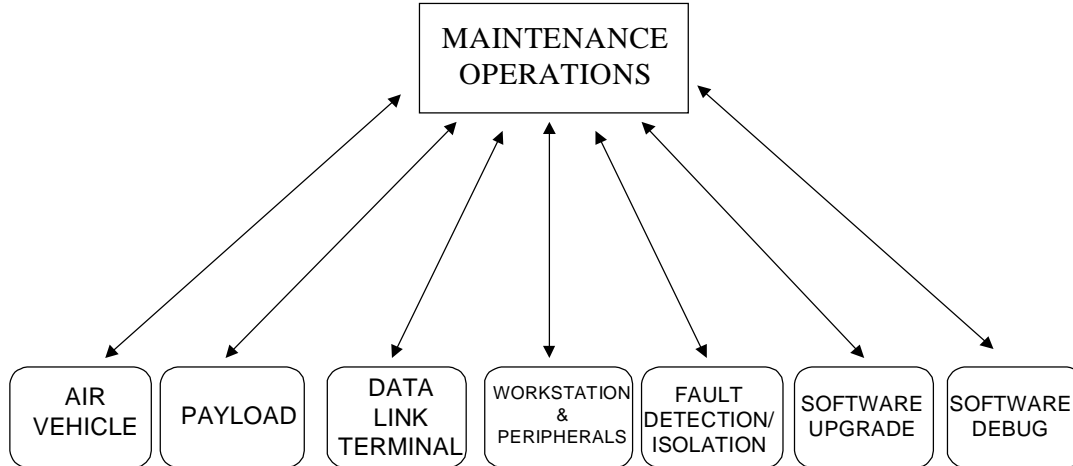Except for software upgrades and debug, all functions can operate concurrently without precluding or excluding any other functions.

3.7 CONFIGURATION. TCS functionality is available in three basic configurations: land-based (LB), mobile unit (MM), and sea-based (SB). The following nomenclature is used to identify these systems:

a. Block: indicates the TCS program block; begins with 0 and increments by 1 whenever upgrades are scheduled.
b. Baseline: indicates the specific version of the system within the block; begins at 1 and increments by 1 whenever a change is incorporated.
c. Version: indicates the specific version within the baseline.
d. Alfa character: indicates a scaleable configuration of the indicated baseline.

As an example, the configuration nomenclature of TCS/SB Block 1, Baseline 1, Version 1A denotes the sea-based configuration of the Block 1 TCS. It is further identified as Version 1A of Baseline 1.

3.7.1 Configuration Options. Each configuration is scaleable and modular to provide options for upgrading or downgrading capability across the different levels of interaction. Options include LOS or BLOS control, single or multiple payload or air vehicle control, EO/IR or SAR imagery processing, and single or multiple TCS workstations. A typical TCS consists of two workstations (a Mission Payload Operator [MPO] and an Air Vehicle Operator [AVO]), associated peripherals (printers, VCR, scan converters, etc), dedicated UAV DCMs, dedicated UAV GDT/antenna control suite and associated hardware (cabling, video subsystem). Each workstation is functionally identical and hosts the image and data displays, route planner, and payload and vehicle controls. Figure 3-7 shows a

standard TCS system configuration capable of LOS operations with Predator and Outrider UAVs for EO/IR imagery.
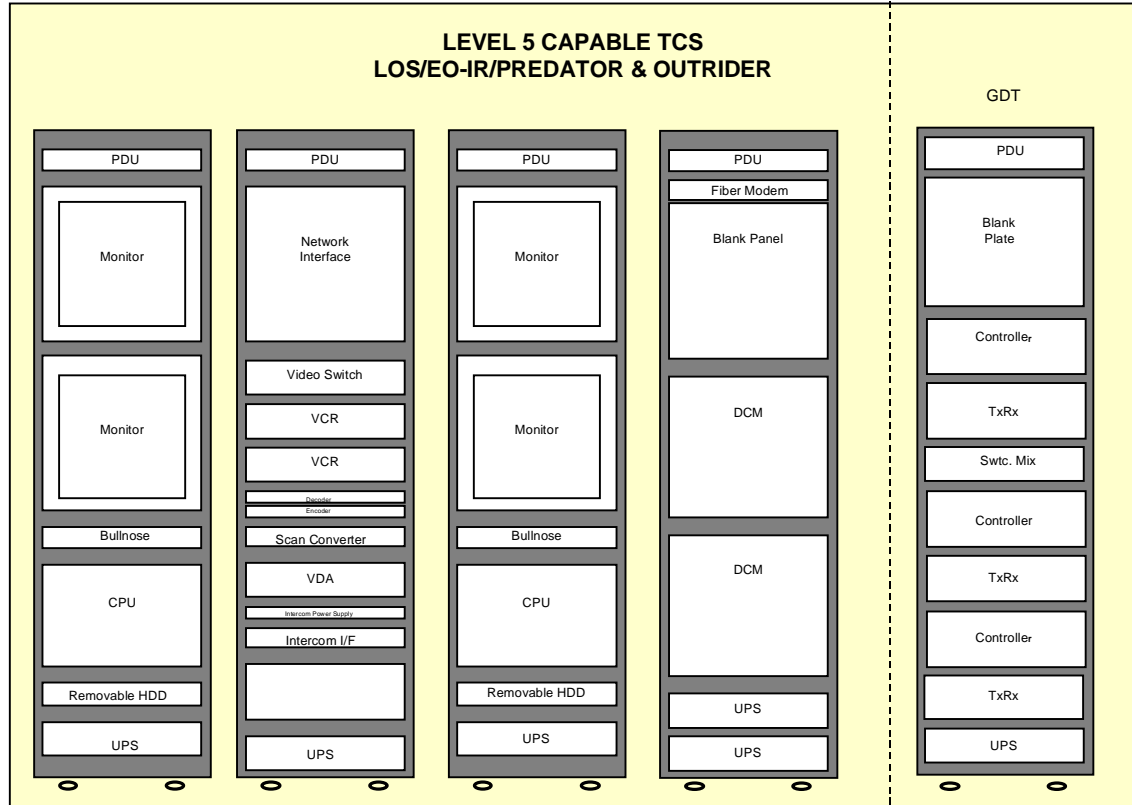
Figure 3-7. Standard TCS Configuration

Configurations differ as capabilities are added or removed. Level 1 operations require a minimum of hardware and software components while Levels 2 through 5 require air vehicle related hardware (GDT/DCMs or IDT and antenna(s)) to allow TCS – air vehicle interaction.

3.7.1.1 Land-Based (LB) Configuration. The notional land-based TCS configuration will be deployed in Army and Marine Corps Tactical Operations Centers (TOCs) located at various echelons of command. The land-based configuration consists of two – or more - workstations, associated peripherals, DCMs, GDTs/IDT, and antennas (LOS, BLOS). The notional configuration includes two workstations, although operational requirements could result in additional workstations being incorporated consistent with space and TCS operator availability.

TCS workstation and peripheral components are packaged in hard shell cases that can be stacked and connected at a deployment site. The land-based configuration is fully transportable by air, land, and sea and is semi-permanent once set-up. Set-up requires approximately xx hours; teardown requires approximately xx hours. *(Note-requires NSWCDD definition). .* Figure 3-8 shows a notional TCS land-based configuration.

Figure 3-8. TCS Land-Based Configuration

3.7.1.2 Mobile Unit (MM) Configuration. The notional mobile unit TCS configuration is incorporated into a HMMWV-mounted shelter and includes two TCS operator workstations, associated peripherals, DCMs, GDTs, and antennas. The mobile unit configuration is fully transportable to the operating area by air, rail, or sea, and is self-mobile once on the ground. The mobile unit configuration requires xx hours to set-up and xx hours to teardown. *(Note-requires additional information on this configuration from NSWCDD).* Figure 3-9 shows a notional TCS land-mobile configuration.

Figure 3-9. TCS Land-Mobile Configuration

3.7.1.3 Sea-Based (SB) Configuration. The notional sea-based TCS configuration can be incorporated into any ship that has undergone the approved TCS ship alteration to provide the system cabling and antennae support necessary and have adequate space to accommodate required TCS components. It consists of two workstations, associated peripherals, DCMs, GDTs, and antennas (LOS, BLOS). TCS/SB is hosted on HP TAC-4 computers and is fully integrated into Joint Maritime Command Information System (JMCIS).

Antenna configuration, polarization, and stabilization is key to successful sea-based TCS Level 3-4 operations. Antenna blockage or destabilization during critical segments of UAV flight or payload control evolutions would most likely result in the loss of UAV data and possibly loss of the air vehicle. Single antenna installations will likely result in signal loss as the ship's superstructure comes between the air vehicle and the data link antenna. In addition, single antenna installation does not provide the capability for simultaneous multiple UAV control. Two-antenna installation provides full double hemispheric coverage and simultaneous multiple UAV control. Antenna hand-off procedures mechanized through a data link switching function are required as the vehicle exits one area of coverage and enters another. Figure 3-10 shows a notional sea-based TCS configuration.

Figure 3-10. TCS Sea-Based Configuration

3.7.2 Integration Into Medium Altitude Endurance (MAE). TCS will be integrated into the MAE Ground Control Station GCS. This will facilitate the dissemination of MAE-derived imagery and data to other TCS nodes or other specified joint or Service C4I system.. TCS is integrated into the data exploitation-mission-planning-communications (DEMPC) terminal segment of the Predator GCS. The DEMPC workstation is the primary means for providing direct and responsive control of the air vehicle and sensor payload. External communications are via high frequency/ultra high frequency/very high frequency (HF/UHF/VHF) voice/data, cellular/landline telephones, and hardwire connectivity with the TROJAN Special Purpose Integrated Remote Intelligence Terminal (SPIRIT) II satellite communications terminal. The current GCS can control only one Predator.

3.7.3 Integration into the OUTRIDER Tactical UAV (TUAV). TCS will be fully integrated into the Outrider GCS. This will facilitate full level 5 TCS at the Outrider control station. *(Need more detailed information)*

3.7.4 Integration into the PIONEER UAV. TCS will be fully integrated into PIONEER and will essentially serve as its ground control station. Pioneer will retain its indigenous Tactical Control Unit that allows for remote flight control of the vehicle. This will facilitate full Level 5 TCS at the Pioneer control station. *(need more detailed information)*

3.8 TCS INTEROPERABILITY. The TCS JORD requires TCS to be fully interoperable with current TUAVs and MAE UAVs and joint and Service C4I systems, and to be interoperable with HAE UAV for imagery receipt. TCS is also required to be interoperable with all future UAVs and joint and Service C4I systems. Open software architecture supports future UAV interoperability by establishing standards, interfaces, and protocols for air vehicle operation and imagery dissemination. TCS is also capable of supporting additional software modules for future payloads and payload capabilities (e.g., autosearch and automatic target tracking) for current UAV systems.

3.8.1 UAV Interoperability.

3.8.1.1 TUAV Interoperability. TCS supports Level 1 through 5 operations with all currently operational TUAV systems (Outrider, Pioneer). Army TUAV operations will employ the current Outrider GCS, converted to TCS mobile unit configuration and a land-based TCS configuration at some TOCs. Navy TUAV operations will use the sea-based TCS configuration. Marine Corps TUAV operations will employ TCS mobile unit configurations, and a land-based configuration at some TOCs.

3.8.1.2 MAE UAV Interoperability. TCS supports Level 1 through 5 operations with the current MAE UAV system (Predator). Air Force MAE UAV operations will use a TCS configuration incorporated into the Predator GCS.

MAE UAV operations by the other Services will use the land-mobile TCS configuration for Army and Marine Corps applications, and the sea-based TCS configuration for Navy operations.

Note: Current Air Force doctrine permits other Services to conduct only Level 1 and 2 MAE UAV operations.

3.8.1.3 HAE UAV Interoperability. TCS supports Level 1 and 2 operations with both the conventional HAE UAV (Global Hawk) and the low observable HAE UAV (Dark Star). This interoperability is achieved by installation of HAE Direct Dissemination Element (DDE) software in the TCS system. This provides all three TCS configurations with the capability to receive, display, store, and retrieve HAE UAV images, dynamically task HAE-UAV sensors, monitor platform and collection status, and participate in video teleconferencing with up to five other locations sharing the same images.

3.8.2 C4I Interoperability. TCS supports Level 1 through 5 operations with most joint, Service, and NATO C4I systems.   This interoperability facilitates the dissemination of imagery and data that can be received from the families of UAVs with which TCS can interact. The TCS system and individual workstations are capable of receiving, displaying, and transmitting a complete complement of imagery types including still imagery, less than full motion video, and full frame, full motion video at 30 frames per second. In general, the TCS system is more capable of receiving and transmitting imagery than the C4I systems with which it is interoperable.

The capability of TCS to receive imagery from a UAV is limited by the capabilities of the communications path (LOS, SATCOM, T-3 line, T-1 line) providing that imagery to the TCS system. The capability of TCS to disseminate that received imagery is limited by the physical hardware and software capabilities of the C4I system to which interfaced. In addition, JFC or Service component commander priorities for imagery dissemination may artificially limit the complete utilization of those capabilities. Physical limitations affecting TCS/C4I interoperability include specific system processing capabilities for image size, frame rate, and transmission speed, the compression techniques employed, and bandwidth availability for imagery dissemination.

TCS supports direct connectivity to standard DOD tactical (VHF, UHF, VHF/UHF, and HF) radios, MSE, and military and civilian satellite communications. TCS integration with C4I systems is accomplished through interfaces that permit information exchange between the TCS and the specified C4I systems. C4I interoperability includes, but is not limited to:

- Advanced Field Artillery Tactical Data Systems (AFATDS)--data burst connectivity
- Advanced Tomahawk Weapons Control Station (ATWCS)
- Air Force Mission Support System (AFMSS)

- All Source Analysis System (ASAS)--wire connectivity
- Automated Deep Operations Coordination System (ADOCS)
- Automatic Target Hand-off Systems (ATHS)--data burst connectivity
- Closed Circuit Television (CCTV)
- Common Operational Modeling, and Simulation System (COMPASS)
- Contingency Airborne Reconnaissance System (CARS)
- Enhanced Tactical Radar Correlator (ETRAC)
- Global Command and Control System (GCCS)
- Guardrail Common Sensor/Aerial Common Sensor (ACS) Integrated Processing Facility (IPF)
- Imagery Analysis System (IAS)--wire connectivity
- Integrated Processing Facility (IPF)
- Joint Deployable Intelligence Support System (JDISS)
- Joint Maritime Command Information System (JMCIS)
- Joint Service Imagery Processing System (JSIPS)
- Joint Service Imagery Processing System - Navy (JSIPS-N)
- Joint Surveillance, Target Attack Radar System (JSTARS) Ground Station Module/Common Ground Station (GSM/CGS)
- JSIPS Tactical Exploitation System (TEG)
- Link 16
- Modernized Imagery Exploitation Station (MIES)
- Precision Targeting Workstation (PTW)
- Tactical Aircraft Mission Planning System (TAMPS)
- Tactical Exploitation System (TES)
- Theater Battle Management Core System (TBMCS)
- TROJAN Special Purpose Integrated Remote Intelligence Terminal (SPIRIT) II

3.9 TCS PERFORMANCE AND LIMITATIONS.

3.9.1 Performance Parameters. TCS is capable of the following:

Being utilized at the following rates: (utilization criteria is based on 30 days/month x 24 hours/day=720 hours/month)

- Peacetime   100 hours/month
- Wartime (90 day surge)   200 hours/month

Operating continuously in the Operation Mode for a minimum of 72 hours.

After emplacement at the operational site, planning and conducting a mission within 1 hour of tasking, to include planning a mission with a minimum of one waypoint, preparing 2 air vehicles (AVs) for flight, setting up a data-link terminal, installing safety equipment, and launching a single AV.

Requiring less than one hour per day of preventative maintenance (PM) on a non-interference basis and less than one hour per week on an interference basis.

Storing xx megabytes (Mb) of imagery for up to yy hours. Imagery can be stored and retrieved in full motion video, less than full motion video, and still image formats. *(Note – requires JWPG definition and consensus).*

3.9.2 System limitations. *To be provided.*

4.0 TCS EMPLOYMENT AND OPERATIONS

4.1 Purpose. This section provides background information and broad guidance concerning the employment and operation of TCS. Emphasis is at the Joint Force Commander (JFC) and Service component commander levels. Information and guidance contained herein is intentionally descriptive in nature rather than prescriptive so as to provide all commanders with the greatest flexibility in determining how best to employ TCS capabilities across the range of military operations.

4.2 Overview. UAVs can be valuable assets to assist a joint force in meeting a variety of theater, operational, and tactical objectives. In combination, endurance UAVs (EUAVs) and TUAVs are significant force enhancers that can help achieve those objectives. UAVs can conduct day or night RSTA tasks, assist in battle damage assessment (BDA), and contribute to force asset management. UAVs are particularly valuable in high-threat environments or heavily defended areas where the loss of high-value, manned systems is possible, and real-time or near-real-time information is required. One challenge for JFCs and their Service component commanders is to achieve synergy among the UAVs available in fulfilling theater, operational, and tactical objectives.

TCS is the tool that enables those commanders to meet that challenge. TCS capability enables commanders to fully integrate and synchronize UAV control and UAV sensor product distribution to achieve unity of effort in joint operations. Although TCS is optimized for tactical operations and has its greatest potential value at that level, it can also contribute to achieving this synergy at the theater and operational levels of operations. The operational value of TCS is in the two unprecedented capabilities it provides: 1) the ability to leverage all current and future UAV assets and their products to support tactical operations throughout the battlespace; and, 2) the ability to integrate all TUAV assets in achieving coherent joint operations.

The strategy to employ available EUAV assets and integrate TCS into theater and operational plans is a JFC responsibility. This strategy should apportion TCS UAV control responsibilities and TCS C4I interfaces to support theater and operational objectives. The JFC strategy should also synchronize theater and operational level TCS distribution of UAV sensor products to support Service component tactical objectives. Complementary strategies to employ component organic TUAV assets and TCS sensor product distribution capabilities in direct support of tactical plans are an individual Service component commander responsibility.

Introduction of TCS capability has outpaced the revision of UAV doctrine. Accordingly, the JFC must consider Service UAV doctrine when developing the theater and operational UAV employment plan and TCS integration strategy. Conflicts may exist between Service doctrine or UAV employment concepts and procedures, and concepts and procedures resulting from the enhanced capabilities TCS provides. When such conflicts are identified, they will be resolved on a case-by-case basis between the JFC and the Service component operational control (OPCON) authority.

4.3 General Employment Concepts. TCS is a tool that provides a fully scaleable and flexible capability to integrate and synchronize the employment of UAV sensor capabilities with the sensor product distribution capabilities of joint and Service C4I systems (e.g., analysis systems, airspace mission planning systems, sensor systems, command and control systems, and fire control systems). Depending upon configuration, TCS can provide the functionality as shown in Figure 4-1.

- RECEIPT & DISSEMINATION OF ANALOG VIDEO & NITF DIGITAL IMAGERY
- VOICE COMMUNICATIONS FOR AIRSPACE CONTROL & INTERFACES FOR TACTICAL VOICE COMMUNICATIONS
- FORMATTING, TRANSMISSION, & RECEIPT OF SELECTED TACTICAL COMMUNICATIONS MESSAGES
- RECORDING & RETRIEVAL OF PAYLOAD DATA
- VIEWING & REVIEW* OF PAYLOAD DATA FROM MULTIPLE PAYLOADS SIMULTANEOUSLY
- CONTROL & MONITORING OF MULTIPLE PAYLOADS SIMULTANEOUSLY
- PLANNING OF UAV MISSIONS
- CONTROL & MONITORING OF MULTIPLE UAVs SIMULTANEOUSLY
- MONITORING THE HEALTH & STATUS OF THE UAV SYSTEM

Figure 4-1. TCS Functionality

* Imagery review capability varies by Service component as a function of operator training –
      Air Force capability – limited imagery exploitation capability (less than 'first phase exploitation') exists with MAE GCS imagery exploitation specialists.
      Army capability – *need Service to fill in*
      Navy capability – *need Service to fill in*
      Marine Corps capability – *need Service to fill in*

The diversity of TCS functionality and the scaleable nature of TCS operator training provide a range of UAV command and control employment options. This also broadens the opportunity to distribute real time and near real time UAV sensor products and information across theater, operational, and tactical echelons of the force through a variety of C4I architectures. Therefore, the proper theater-level, operational-level, and tactical-level employment of TCS capability is central to achieving the optimum synergy of available UAV capability.

Considerations affecting TCS employment are shown in Figure 4-2.

- NUMBER AND TYPES OF UAVS AVAILABLE
- THEATER, OPERATIONAL, AND TACTICAL NEEDS FOR THOSE UAVS
- NUMBER AND CONFIGURATION OF TCS SYSTEMS AVAILABLE
- TCS OPERATOR QUALIFICATIONS/CURRENCY
- C4I EXPLOITATION ARCHITECTURES AND CAPABILITIES AVAILABLE WITHIN THE FORCE
- FREQUENCY MANAGEMENT CONSIDERATIONS AND PRIORITIES (DATA, VOICE, ETC.)
- EXPLOITATION ASSETS AVAILABLE TO RECEIVE TCS DATA
- OPERATING ENVIRONMENT
- CONTROLLED NATIONAL AIRSPACE CONSIDERATIONS
- SERVICE DOCTRINE OF THE UNITS EXERCISING OPCON OF THE UAV(S)
- RULES OF ENGAGEMENT

Figure 4-2. TCS Employment Considerations

TCS can be employed in three baseline configurations: land-based, land-mobile, and sea-based (see Section 3.8.1). Each baseline configuration has a notional capability that can be modified to meet JFC or Service component needs.

With appropriate training (see Appendix E), existing operator and maintenance personnel available within Service UAV units are sufficient to properly employ TCS at all levels of functionality. For high tempo operations, however, it may be operationally prudent to augment such units with additional TCS-qualified operator and maintenance personnel from units not directly supporting the operation. The operating environment, the required pace of operations, TCS system configuration (level of functionality and number of operator consoles), and whether single or multiple UAV control is required will dictate the manpower needs for specific situations. For short periods of time a single qualified operator may control both a payload and an air vehicle, based upon the operational tasking environment. The operating Service will determine the optimum duty cycle for TCS operators. With appropriate training, non-UAV units are capable of employing TCS at Levels 1 and 2, but will likely require personnel to be reassigned within the organization to collaterally serve as TCS operators and maintenance technicians. These personnel will require more extensive training than personnel from UAV units.

The general employment concepts presented in this section and the notional concepts presented in section 4.4, Specific Employment Concepts, provide representative applications of TCS capability in a variety of scenarios across the military continuum. These representative applications provide a baseline from which employment options may be considered and decisions regarding specific applications of TCS may be made.

4.3.1 TCS Organization. TCS capability is integrated with all MAE UAV and TUAV units. TCS capability may also be integrated into non-UAV units as directed by appropriate authority. Command authority (COCOM), OPCON, and administrative control (ADCON) of TCS capability is exercised through normal organizational command structures.

Geographic CINCs are COCOM of all Service component forces assigned under the Secretary of Defense (SECDEF) "Forces For Unified Commands" memorandum, including all TCS-capable TUAV units, and all temporarily TCS-capable, non-UAV units. USCINCACOM is also COCOM of all MAE UAV forces. OPCON of TCS-capable units will be exercised through JFCs and individual Service component commanders. ADCON of TCS-capable units is an individual Service component commander responsibility.

4.3.1.1 COCOM Responsibilities. Combatant commanders exercising command authority over TCS-capable forces will employ them to meet own theater operational and training needs, and will deploy TCS-capable forces to satisfy the operational and exercise requirements of other CINCs when the Joint Staff directs such support.

4.3.1.1.1 TCS Deployment. Operational deployment of TCS-capable units will be coordinated between the supported and supporting COCOM authorities. Exercise deployment of TCS-capable units will be coordinated between USCINCACOM and the supported commander. Intra-theater transportation for TCS-capable units with land-based or land-mobile TCS configurations will normally be by air; in-theater transportation may be by ground, rail, or air. Deployment of TCS-capable naval units must be accomplished by deploying ships already outfitted and configured with TCS.

4.3.1.1.2 TCS-Capable Unit Basing. Unless specifically directed otherwise by the COCOM authority, basing of both UAV and non-UAV TCS-capable units will normally follow Service component command echelon plans.

4.3.1.2 OPCON Responsibilities. JFCs and Service component commanders exercise OPCON of assigned and attached TCS-capable units. OPCON responsibility includes providing housing, security, messing, health care, and

supply support for TCS-capable units deployed in support of operational or exercise requirements. Service component OPCON responsibility also includes decision authority regarding employment of TCS-capable units in Service operations, exercises, and demonstrations.

The OPCON authority also has responsibility to provide the required C4I connectivity to support TCS imagery processing, exploitation, and dissemination (PED). In addition, where non-organic TCS control of air vehicles or payloads is anticipated, the OPCON authority should provide the necessary communications path(s) to coordinate handoffs between TCS units.

4.3.1.3 ADCON Responsibilities. Service component commanders exercise ADCON of TCS-capable units. TCS logistics support is an ADCON authority responsibility.

4.3.2 TCS Management Concept. TCS adds a new dimension to UAV employment, intelligence collection management, and sensor product distribution. Existing joint and Service component processes and procedures are adequate to meet the challenge of that new dimension at the tactical level of operations. The processes that currently manage organic TUAV employment within the Service components and coordinate intelligence collection and distribution of UAV sensor products at the tactical level of operations are sufficient to accommodate the necessary management of TCS. By default, tactical TCS employment will be a natural by-product of the coordination of these two processes.

Those same processes and procedures are not optimized, however, to deal with the theater and operational level management challenges posed by TCS. The proper employment of theater and operational UAVs and integration of theater and operational level intelligence collection and distribution requirements is a JFC responsibility. A JFC cell comprised of representatives from J2, J3, and J6 should be created to develop the JFC strategy for TCS employment within the force and to manage the integration of EUAV assets and intelligence collection requirements in support of theater and operational needs. The cell will also allocate EUAV capability and sensor product distribution to meet service component tactical needs. To assist in executing this responsibility, TCS qualified liaison officers (LNOs) from Service components may be required to augment this JFC cell.

Specific TCS management responsibilities of this cell include maintaining knowledge of UAV and TCS capabilities assigned and attached to the joint force, the location and readiness of TCS-capable units, and Service component organic TCS employment plans and non-organic support requirements. The cell is primarily responsible to the JFC, through the J3, for managing the routine employment of available EUAV capability in support of the JFC's theater and operational RSTA, BDA, and battle management needs and for allocating EUAV capability in support of tactical needs. This cell will assign TCS functionality to TCS capable units supporting the JFC and identify C4I interfaces

for the distribution of sensor products. The cell is also responsible for directing supported-supporting relationships among Service components when non-organic TCS support is necessary to specific operations or excess TCS capability could benefit another component's operations. The cell can also direct Service component organic TCS capability to temporarily support theater and operational needs, when required, and dynamically retask Service component TCS units, if necessary.

Existing communications paths and procedures will be utilized to promulgate the JFC Cell's TCS management plan in the form of a TCS Tasking Order (TTO). The TTO will be similar in form and function to the Air Tasking Order (ATO) issued by the Joint Force Air Component Commander (JFACC) to conduct the daily allocation of air assets. It will prescribe the planned daily allocation of TCS assets directly supporting the JFC, including UAV mission assignments, sensor priorities, time periods and levels of TCS functionality assigned to various TCS equipped units, handoff points and times, and other pertinent operational information. The TTO will also detail the requirements for TCS product dissemination. Except when required to support theater and operational requirements, the TTO will not address Service component TCS allocation. The TTO will be used by TCS equipped units assigned air vehicle and payload control responsibilities to develop UAV mission profiles and flight plans. UAV mission and flight plan information will be provided to the JFACC for incorporation into the air allocation process and inclusion in the ATO.

4.3.3 Service Employment Concepts. When assigned to a joint force or attached to support a joint operation, TCS equipped Service components will conduct TCS operations in accordance with this CONOPS and as directed by the JFC.

For single Service operations with multiple TCS systems, TCS allocation will be determined in accordance with Service doctrine. In single Service operations the responsible airspace control authority (ACA) will be provided UAV flight plans and will coordinate them with other flights in the area of operations. In operations where coordination is required with national airspace authorities, the UAV launch and recovery unit is responsible for conducting that coordination.

> **4.3.3.1 Air Force.** Air Force currently operates MAE UAVs to support national, theater, and operational tasks as directed by theater CINCs. In the future, Air Force will also operate HAE UAVs to support national, theater, and operational tasks as required.
>
> TCS offers the opportunity to expand Air Force UAV support at the tactical level of military operations by providing both indirect and direct delivery paths for MAE and HAE imagery products to C4I systems. Such support involves RSTA tasks for deep strike operations or TBMD, or naval gunfire support, maritime surface search and control, or amphibious landing support.

In addition, Air Force UAV operations with TCS provide the avenue for Air Force component forces to receive UAV intelligence, surveillance, and reconnaissance (ISR) information from other Service components. This information may aid in the optimum application of air power against selected targets or in sensor-to-shooter scenarios. TCS also enables Air Force component TOCs to access imagery from other Service component UAVs when MAE or HAE imagery may not be available due to weather or other conditions. The ability to leverage off in-theater UAV assets through TCS also reduces the UAV deployment requirements for an Air Expeditionary Force (AEF) deployment during the early, critical buildup stage.

4.3.3.2 Army. Army will operate a TUAV system to provide RSTA and battle management direct mission support to commanders at the Division, Armored Calvary Regiment (ACR), and Brigade echelons. The capabilities of this system will be enhanced when it is employed as part of an overall collection plan and fully integrated with and cued by other intelligence collection systems, including other UAVs, in a synchronized effort.

Army notional TCS configuration consists of a HMMWV-mounted shelter with two crew-oriented, independently functioning and interoperable workstations for TCS air vehicle control equipment directly related to UAV systems.

TCS offers Army commanders the potential to integrate multiple TUAV, and MAE and HAE UAV ISR products in support of the ground maneuver commander's RSTA effort. TCS also provides the avenue for Army operated TUAV ISR products to be distributed to other Service components and elements of a joint force.

Army objectives include providing UAV imagery to JSTARS CGS. This can be accomplished by hosting TCS on the CGS workstation, collocating TCS with CGS and providing both with the same data link receiver elements, or with TCS supporting CGS from a remote location via Global Broadcast Service (GBS), JWCIS, JDISS or similar secondary imagery transmission system.

4.3.3.3 Navy. Navy will employ organic TUAVs and intends to utilize TCS to integrate all UAVs in support of maritime and expeditionary RSTA functions. Navy ability to receive and disseminate real time UAV data via TCS is critical to effective imagery support of a multitude of operations including strike warfare, communications/data relay, electronic warfare (EW), deep strike, naval surface fire support (NSFS), close air support (CAS); deep, shallow, and surf zone operations, and special operations conducted by Navy forces.

TCS will act as a force multiplier by providing scaleable, direct and indirect UAV system control and data dissemination to all naval forces operationally capable of

employing TCS. In addition, TCS provides naval forces the ability to utilize non-organic UAV assets to support all maritime operations out to the maximum effective ranges of naval weapons systems and aircraft.

TCS provides the means to diversify the methods by which UAVs are deployed/employed and enables the "cross-decking" of UAV systems and or qualified Navy, Marine Corps, or Air Force TCS operators to support UAV operations from a vast variety of naval vessels.

4.3.3.4 Marine Corps. The Marine Corps will utilize TCS to conduct UAV operations in support of amphibious operations from naval vessels, as well as in support of Marine Air-Ground Task Force (MAGTF) operations. TCS will provide a means to control UAVs and disseminate UAV data to Aviation Combat Element (ACE)/Ground Combat Element (GCE) Commander(s), across a wide spectrum of operations, and provide a means to disseminate data from non-organic UAV systems. TCS will allow other Services with compatible TCS systems to operate Marine Corps organic TUAVs in support of Operational Maneuver from the Sea/Amphibious Operations, while Marine and other landing forces are phasing ashore, providing RSTA/tactical coverage to commanders until landing force facilities ashore become operational.

TCS will support a variety of UAV operational and tactical tasks, afloat and ashore, by maximizing the effective ranges of Marine Corps weapons systems and aircraft.

4.4 Specific Employment Concepts. In its full configuration, TCS operates at five levels of increasing functionality. Those levels of functionality, the flexibility with which TCS can be employed, and notional TCS employment considerations are discussed in the following paragraphs. The discussion of each level of functionality is supported with a representative scenario to notionally demonstrate how that level of functionality might be employed.

4.4.1 Level 1. Level 1 TCS operations provide a new dimension to warfighting by enabling the dissemination of UAV imagery to a wider variety of users totally independent of air vehicle or payload control requirements.

Level 1 TCS functionality involves passive receipt of UAV sensor products through an indirect path. Level 1 functionality also provides for further dissemination of UAV imagery if operationally required. Level 1 TCS operations involve no interaction between UAVs providing imagery and TCS workstations receiving that imagery.

4.4.1.1 Operational Considerations. Level 1 operations are feasible with both UAV units and non-UAV units. Level 1 operations are a subset of higher level operations by another TCS disseminating imagery to a C4I system or other TCS

systems. Level 1 TCS operations do not require communications connectivity with any other node.

4.4.1.1.1 Mission Planning. Level 1 TCS functionality does not provide mission planning capability.

4.4.1.1.2 Handoff Procedures. Not required.

4.4.1.1.3 Personnel. Additional personnel are not required to support Level 1 TCS operations.

4.4.1.1.4 Training/Qualification/Currency Standards. Level 1 TCS operations require minimal TCS related training. TCS operators require completion of the TCS Core course (see Appendix E). There are no unique currency standards for Level 1 operations.

4.4.1.2 Service Component Level 1 Capabilities. The following Service component forces/units will be capable of Level 1 TCS operations:

Air Force:
- Air Operations Center (AOC)
- Wing Operations Center (WOC)
- Imagery Exploitation System (IES)
- UAV Exploitation System (UES)

Army (HAE only):
- TUAV shelter
- TOC

Coast Guard:
- TBD

Marine Corps (HAE only):
- TOC

Navy (HAE only):
- Attack submarine (nuclear) (SSN)

Special Operations Command (SOC):
- TBD

Level 1 Representative Scenario
Major joint military campaign.
Mission: Prepare to conduct full-scale joint combat operations to defeat the enemy. Employ all available national, theater, and tactical ISR assets during the buildup phase to accomplish intelligence preparation of the battlefield.
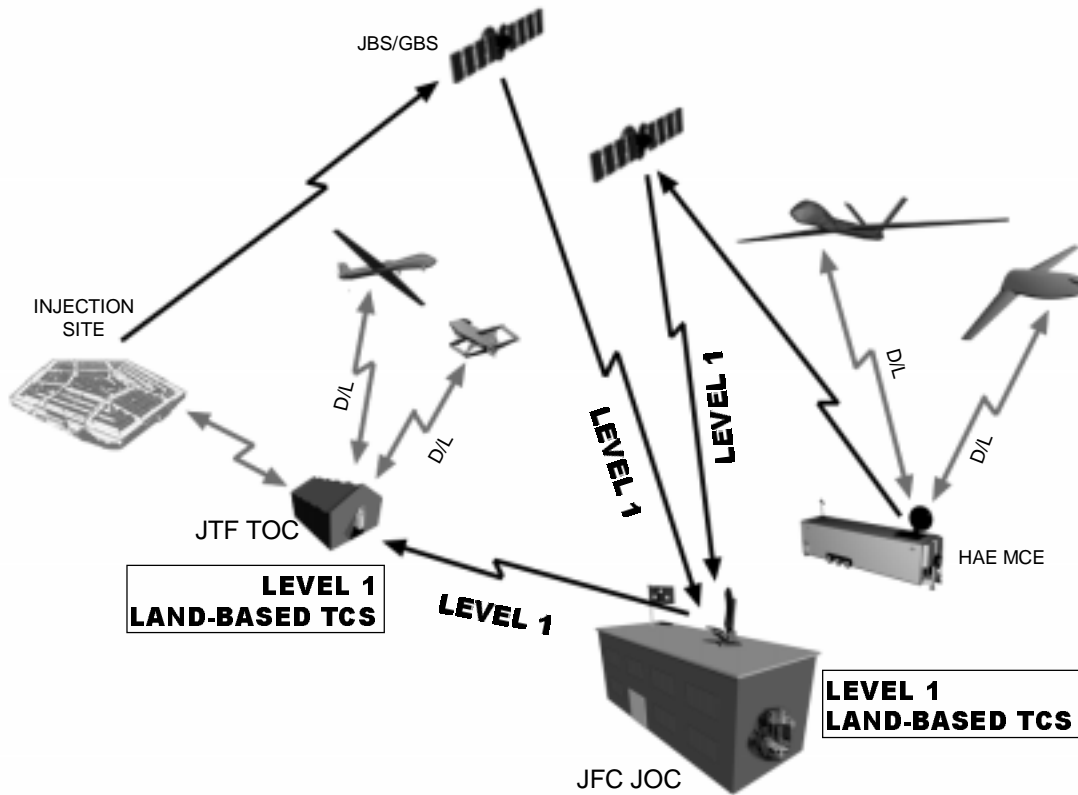
Figure 4-3. Level 1 TCS

TCS Employment Concept

The JFC desires to use national, theater, and tactical UAV assets to obtain imagery of the disposition of enemy forces and to maintain that picture until the start of hostilities. The JFC assigns both conventional and LO HAE UAV assets (TCS Level 1 compliant) to provide SAR imagery support to the JFC JOC, where selected imagery is further disseminated to the JTF TOC. MAE UAV TCS-controlled assets are assigned to provide direct SAR imagery support to the JTF TOC that further disseminates the imagery to the JFC JOC. TUAV assets are assigned to provide EO/IR imagery support to the JTF TOC. The JFC JOC and JTF TOC are both TCS Level 1 capable.

4.4.2 Level 2. Level 2 operations enable a wide range of operational users to receive imagery and data directly from UAVs. This can speed the flow of information to units that need it most in a specific operation, because the information is unfiltered and unprocessed at intermediate echelons. This provides operational commanders with increased flexibility in planning UAV operations and in disseminating UAV products, but poses additional management burdens.

Level 2 TCS functionality involves receipt of UAV sensor products through direct interaction between TCS workstations and UAVs. Level 2 TCS operations may also include dissemination of UAV sensor products to other TCS workstations or C4I systems.

4.4.2.1 Operational Considerations. Level 2 operations are feasible with both UAV and non-UAV units. Level 2 operations require receiving TCS workstations to be within the downlink footprint of the UAV and to have an antenna and GDT capable of receiving the downlink signal from the UAV(s). Level 2 TCS operations do not require communications connectivity with any other node.

4.4.2.1.1 Mission Planning. Level 2 TCS functionality does not provide mission planning capability.

4.4.2.1.2 Handoff Procedures. Not required.

4.4.2.1.3 Personnel. Additional personnel are not required to support Level 2 TCS operations.

4.4.2.1.4 Training/Qualification/Currency Standards. Level 2 TCS operations require minimal TCS related training. TCS operators require completion of the TCS Core course (see Appendix E). There are no unique currency standards for Level 2 operations.

4.4.2.2 Service Component Level 2 Capabilities. The following Service component force/units will be capable of Level 2 TCS operations:

Air Force (Predator and HAE only):
  UES
Army:
  Brigade
  ACR
  Division
  Corps
  Army
  Military Intelligence Brigade (Echelons above Corps)
  SOF
  Training Base
  Reserve Component Separate Brigade
Coast Guard:
  TBD
Marine Corps:
  N/A
Navy (HAE only*):
  Aircraft carrier (CV)
  Amphibious assault ship (LHA)/amphibious assault ship (internal dock) (LHD)
  Amphibious transport dock (LPD)
  CruDes (cruiser-destroyer) ships

          Amphibious command ship (LCC)
SOC:

    TBD

* Note: Current HAE/TCS interaction capability provides for Level 1 operations only.

Level 2 Representative Scenario

Non-combatant evacuation operation (NEO) in a potentially non-permissive environment. Mission: Conduct helicopter evacuation of US citizens and key foreign nationals from a designated airfield. Provide perimeter protection throughout the evacuation process.
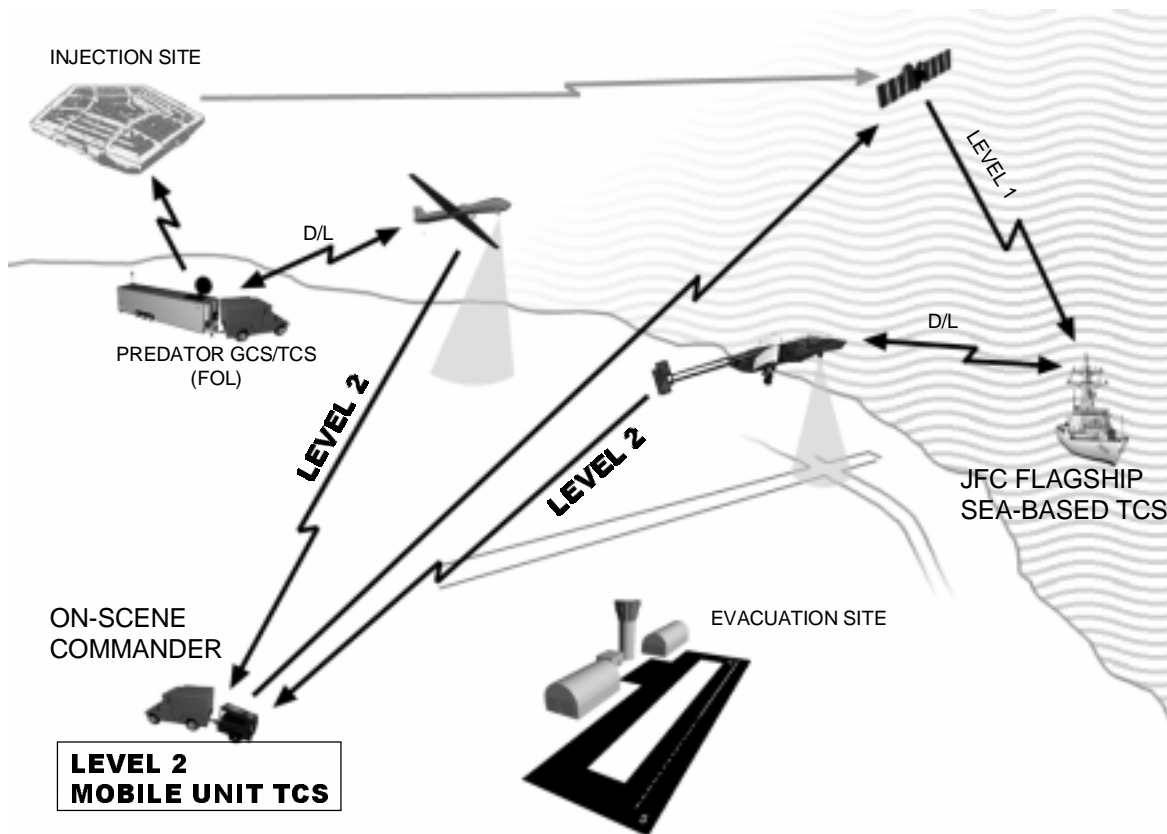
Figure 4-4. Level 2 TCS

TCS Employment Concept

The JFC desires to support the NEO force with imagery of the surrounding environs to enable early and swift application of defensive forces as required. The JFC assigns MAE TCS-controlled assets and sea-based TUAV assets to provide the NEO force with direct EO/IR imagery. The NEO force tactical operations center TOC (ashore) is Level 2 TCS capable. The

JFC (embarked) is receiving Level 1 TCS UAV imagery through SATCOM connectivity to the MAE and TUAV TCS systems ashore.

4.4.3 Level 3. Level 3 enables operational commanders to assign payload control responsibilities directly to the key users of the information to be gathered during a specific UAV flight or portion of a flight independent of air vehicle control.

Level 3 TCS functionality involves real time control of UAV payloads and both pre-flight and real time payload mission planning. Level 3 TCS operations may also include dissemination of UAV sensor products to other TCS workstations or C4I systems.

Note: Current legacy UAV systems use the same data link uplink signal for payload and air vehicle control. Therefore, the TCS workstation exercising payload control (Level 3) requires digital connectivity with the TCS workstation exercising air vehicle control (Level 4) in order to provide payload control commands to the uplink signal.

4.4.3.1 Operational Considerations. Cross-component Level 3 operations by both UAV and non-UAV units are feasible with appropriate training and any UAV-peculiar manual control equipment to control the payload of the UAV(s) being utilized. Level 3 TCS operations do not require communications connectivity to any other node, however, communications between payload operators and air vehicle operators may improve mission coordination.

4.4.3.1.1 Mission Planning. Level 3 TCS functionality provides preflight payload planning capability and the ability to dynamically retask the payload.

4.4.3.1.2 Handoff Procedures. Handoff procedures, specific to the UAV and associated payload being operated, are required between the air vehicle operator and payload operator(s), including workstation recognition of positive handoff.

4.4.3.1.3 Personnel. Additional personnel are not required to support Level 3 TCS operations, however, temporary assignment of additional personnel may be operationally prudent to conduct operations involving simultaneous or multiple payload control.

4.4.3.1.4 Training/Qualification/Currency Standards. Level 3 TCS operations require TCS related training. TCS operators require completion of the TCS Core course (see Appendix E) and may require Service specific payload operator training and qualification. Payload operator currency standards are as required by individual Services for their UAVs.

4.4.3.2 Service Component Level 3 Capabilities. The following Service component force/units will be capable of Level 3 TCS operations:

Air Force:

N/A

Army:

Corps

Military Intelligence Brigade (Echelons above Corps)

Coast Guard:

TBD

Marine Corps:

N/A

Navy:

N/A

SOC:

TBD

Level 3 Representative Scenario
JTF ashore is conducting MOOTW peacekeeping operations.
Mission: Monitor and report belligerent compliance with United Nations (UN) sanctions.
Intervene as necessary, short of armed hostilities, to ensure sanction compliance.
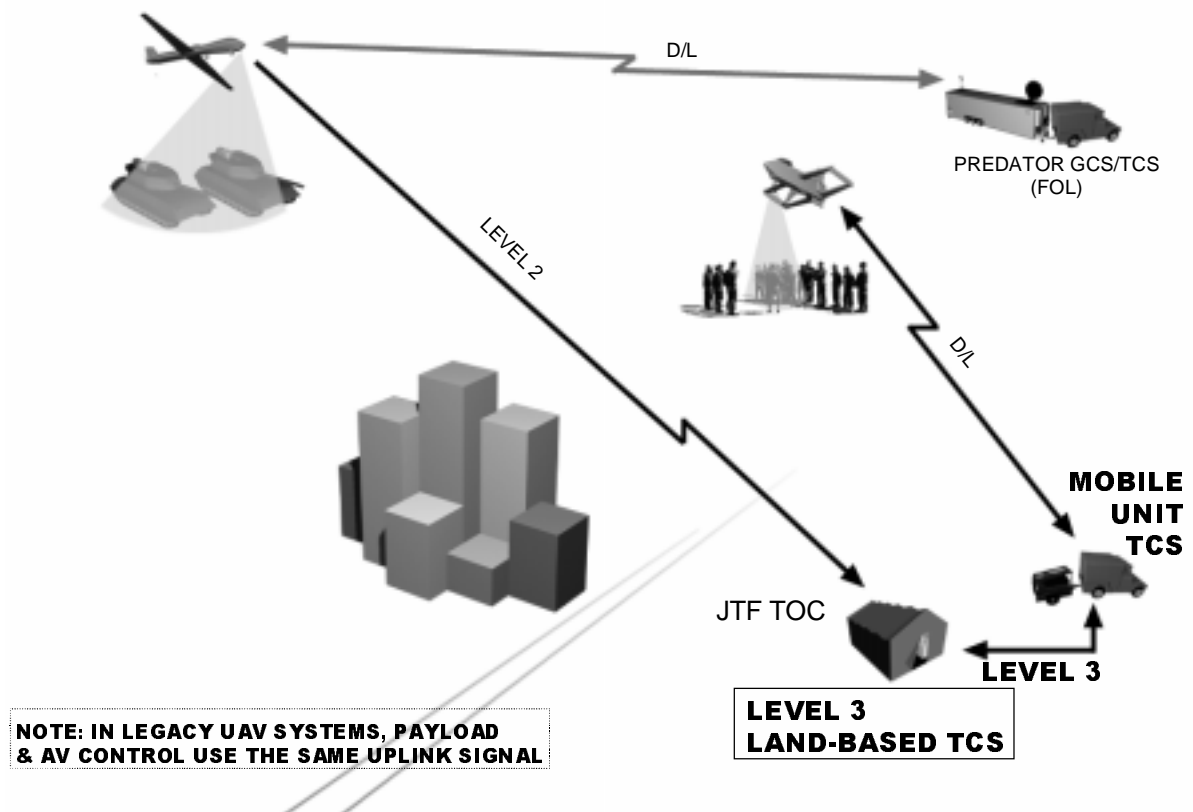
Figure 4-5. Level 3 TCS

TCS Employment Concept
The JFC desires to optimize the application of limited forces in achieving mission objectives. To improve the ability to command and control this process, the JFC desires to receive real time imagery at his headquarters. The JFC assigns Level 3 EO/IR payload control to the headquarters TOC for assigned TUAV assets. Payload control is exercised through connectivity to the air vehicle control TCS collocated with the JTF TOC. Level 2 support from MAE assets is also assigned to augment TUAV operations and to permit direct receipt of MAE SAR imagery.

4.4.4 Level 4. Level 4 allows a TCS control node other than the launching and recovering station to control the flight of the air vehicle. This enables air vehicle control to be assigned in direct support of an operational commander. This provides that commander with the capability to employ the air vehicle and payload to best meet that force's needs and to speed the delivery of the UAV product to the correct echelon(s) of the force.

Level 4 functionality involves real time control of air vehicles and both pre-flight and real-time air vehicle mission planning. Level 4 operations may also include dissemination of UAV sensor products to other TCS workstations or C4I systems.

4.4.4.1 Operational Considerations. With proper training, cross-component Level 4 operations are feasible by UAV units. Level 4 operations by non-UAV units are not recommended due to the training required to develop the operational capability. Level 4 TCS operations do not require communications connectivity to any other node, however, communications between air vehicle operators and the launch and recovery operator may improve mission coordination.

4.4.4.1.1 Mission Planning. Level 4 TCS functionality provides preflight mission planning capability and the ability to dynamically retask the air vehicle in flight.

4.4.4.1.2 Handoff Procedures. Handoff procedures between air vehicle operators and the launch and recovery operator are required, including workstation recognition of positive handoff.

4.4.4.1.3 Personnel. Additional personnel are not required to support Level 4 TCS operations, however, temporary assignment of additional personnel may be operationally prudent to support high tempo operations.

4.4.4.1.4 Training/Qualification/Currency Standards. Level 4 TCS operations require TCS related training. TCS operators require completion of the TCS Core course for single UAV operations and completion of the TCS Advanced course for multiple UAV operations (see Appendix E). TCS operators may also require Service specific air vehicle operator training and qualification. Service requirements for air vehicle operator currency may also apply.

4.4.4.2 Service Component Level 4 Capabilities. The following Service component force/units will be capable of Level 4 TCS operations:

Air Force:

N/A

Army:

Reserve Component Separate Brigade

Coast Guard:

TBD

Marine Corps:

TBD

Navy:

CV (Outrider, Pioneer, and Predator*)

LHA/LHD (Pioneer and Predator*)

LPD (Outrider and Predator*)

CruDes ships (Outrider, Pioneer, and Predator*)

LCC (Outrider, Pioneer, and Predator*)

SSN (Outrider, Pioneer, and Predator*)

SOC:

TBD

Note: Current Air Force policy permits only Air Force control of Predator.

Level 4 Representative Scenario

Amphibious task force (ATF) conducting an amphibious operation.

Mission: Conduct a joint amphibious landing to seize military objectives ashore. Transfer joint force command ashore once objectives are seized.
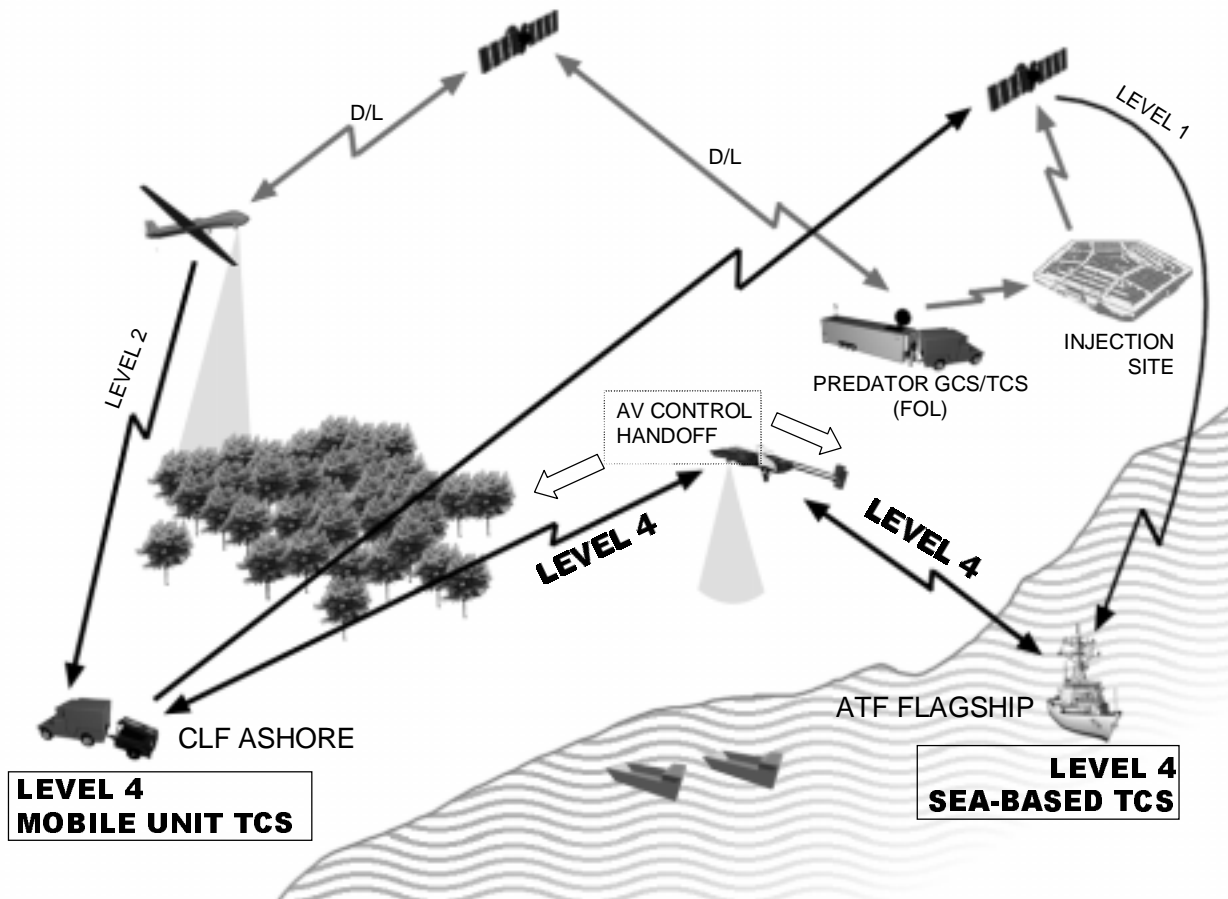
Figure 4-6. Level 4 TCS

TCS Employment Concept

The JFC desires to use real-time imagery prior to commencement of the landing operation to assist in intelligence preparation of the battlefield (IPB). Once the amphibious landing is commenced, real time imagery will support targeting and bombardment of key targets ashore by Naval surface fire support. Once forces are ashore, real time imagery will support further maneuver of those forces and establishment of the lodgment. The JFC assigns Level 4 TUAV control to the ATF flagship prior to and during the landing for EO/IR imagery, and assigns Level 4 TUAV control for EO/IR imagery to the Commander, Landing Force (CLF) TOC once established ashore. MAE TCS-controlled assets are also assigned to provide SAR imagery through Level 1 to the ATF flagship and through Level 2 to the CLF ashore.

4.4.5 Level 5. Level 5 provides all of the operational advantages and flexibility of Levels 1 through 4, but incurs the additional responsibility for air vehicle launch and recovery, beddown, and support.

Level 5 functionality involves manual or automated launch and recovery of the air vehicle. Level 5 operations may also include dissemination of UAV sensor products to other TCS workstations or C4I systems.

4.4.5.1 Operational Considerations. Cross-component Level 5 operations are not operationally feasible, however, launch of a UAV by one TCS workstation and subsequent recovery by a different TCS workstation within the same Service component provides added operational flexibility.

Note: Current Service reporting custodian policies permit UAV launch and recovery operations by the parent Service only.

4.4.5.1.1 Mission Planning. Level 5 TCS functionality provides preflight mission planning capability and the ability to dynamically retask the air vehicle in flight.

4.4.5.1.2 Handoff Procedures. Handoff procedures between air vehicle or payload operators and the launch and recovery operator are required, including workstation recognition of positive handoff.

4.4.5.1.3 Personnel. Additional personnel are required to prepare the air vehicle for launch and to service it upon recovery. For Pioneer, an external pilot (EP) is required to launch and recover the air vehicle.

4.4.5.1.4 Training/Qualification/Currency Standards. Level 5 TCS operations require TCS related training. TCS operators require completion of the TCS Core course and the TCS Advanced course plus Service specific UAV training curricula (see Appendix E). Service requirements for air vehicle operator currency also applies.

4.4.5.2 Service Component Level 5 Capabilities. The following Service component force/units will be capable of Level 5 TCS operations:

Air Force:
       Predator GCS

Army:
       Brigade
       ACR
       Division
       Corps
       Military Intelligence Brigade (Echelons above Corps)
       Training Base

Coast Guard:
       TBD

Marine Corps (Pioneer and Outrider):
       TOC

Navy:

LHA/LHD (Outrider only)
LPD (Pioneer only)
SOC:
TBD

Level 5 Representative Scenario
Ground force component battlefield maneuver.
Mission: Maneuver to engage and defeat enemy ground forces in garrison positions.
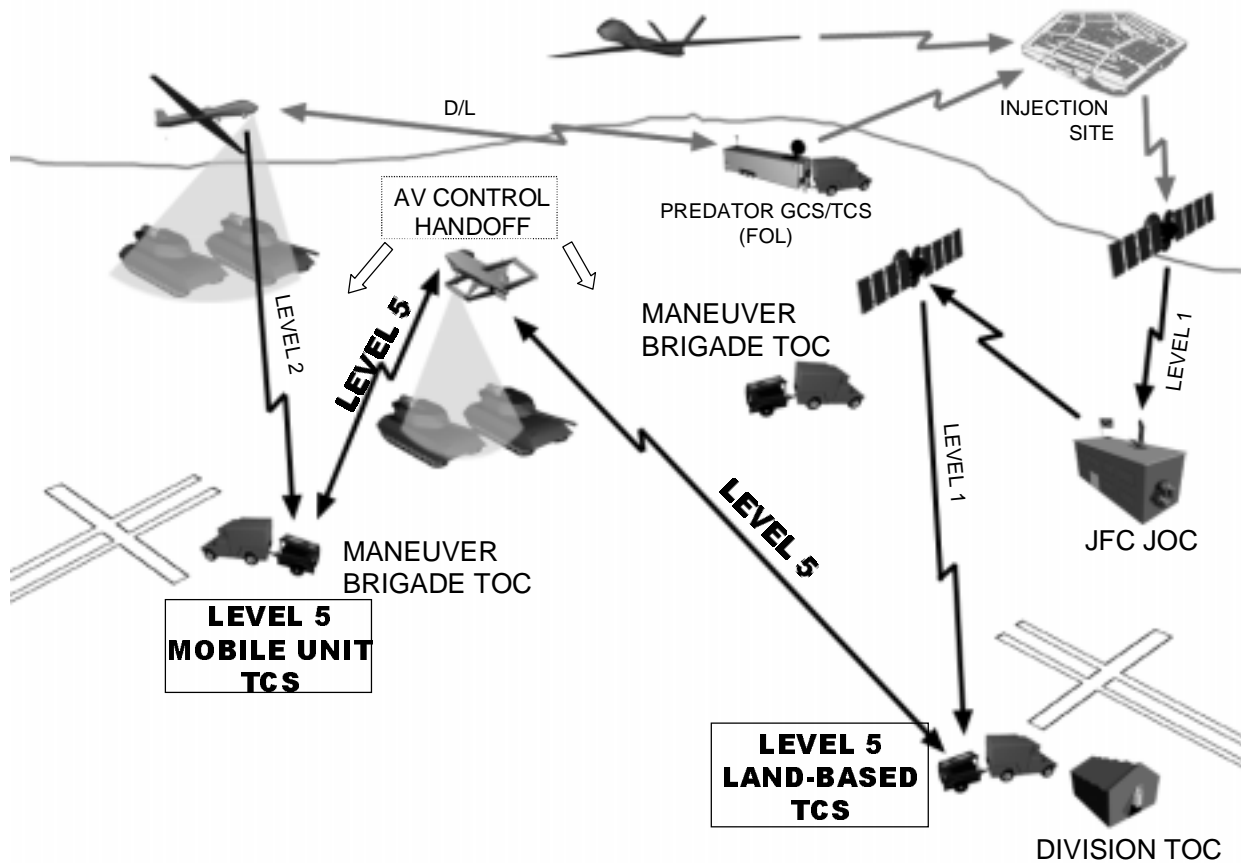
Figure 4-7. Level 5 TCS

TCS Employment Concept
The JFC has initiated combat operations against the enemy. Tactical operations include an air and ground campaign. The ground component commander desires to support the maneuver of tactical ground forces with imagery for RSTA. The ground component commander has assigned Level 5 direct support control of organic TUAV assets to maneuver brigades for EO/IR targeting of enemy forces and has authorized the launch of TUAV assets from one location with subsequent handoff and recovery at another location as the tactical situation warrants. The JFC

has also assigned Level 2 MAE SAR imagery support to ground forces within the MAE footprint. The JFC will also support the ground component commander's TOC with Level 1 TCS imagery from HAE and MAE assets.

5.0 OTHER EMPLOYMENT CONCEPTS

5.1 Purpose. To summarize additional considerations and factors which influence the operational planning and employment of TCS.

5.2 Safety.

5.2.1 Controlled Airspace Operations. Current Federal Aviation Administration (FAA) and International Civil Aviation Organization (ICAO) regulations neither endorse nor provide procedures for the employment of UAVs across national and international divisions of airspace. In some countries and geographic areas, UAV flight is strictly controlled or prohibited. Both the FAA and ICAO are considering amendments to standing regulations to clarify and establish a methodology for integrating manned and unmanned systems in controlled airspace. Until a unified set of standards is established, TCS operation of UAVs in controlled airspace will have to be coordinated on a case-by-case basis with the governing airspace organization.

5.2.2 TCS Operator Training and Qualifications. TCS operators require initial training and qualification for the level of operations to be performed, however, there are no specific warfighting or military specialty skills required to be selected as a TCS operator. Additionally, TCS operators conducting Level 3, 4, and 5 operations also require currency in the level of operations to be performed and with the specific air vehicle(s) being controlled.

The TCS system is designed to minimize training requirements for TCS operators. Initial training requirements are a function of trainee experience and the TCS operating level being trained to, and for Levels 3, 4, or 5, whether those operations are single vehicle or multi-vehicle (two or more of the same or different air vehicles) operations. TCS operator initial training for Levels 1 and 2, and currency maintenance for all levels will be accomplished through computer-based training (CBT) to the maximum extent possible. TCS Level 4 and 5 operator training may also require training and qualification in appropriate controlled airspace procedures to satisfy FAA/ICAO unmanned air vehicle pilot requirements.

Specific TCS operator training, qualification, and currency standards and maintenance training requirements are detailed in Appendix E. In addition to meeting initial training, qualification and currency requirements for the level of TCS operations that they will perform, TCS operators must also meet Service specific air vehicle or payload control qualification and currency requirements.

5.2.3 Air Vehicle Handoff. Pre-planned or dynamically retasked handoffs of air vehicle control between TCS operators must be properly coordinated. Exact handoff procedures

will be specific to the air vehicle involved and must be clearly understood by both TCS operators.

The following guidelines apply to TCS air vehicle handoffs:

- The transferring and receiving TCS stations must be able to communicate real time or pre-arrange the handoff.
- The air vehicle commanded parameters must be matched by the transferring and receiving TCS stations to avoid tremendous/abrupt flight path changes at the point of handoff.
- In addition, for air vehicles with a second transmitter (e.g., Pioneer):
  - The transferring TCS station, after confirming the receiving TCS station is ready to assume control, turns off its secondary transmitter. The receiving TCS station, upon noting air vehicle indication that secondary link is off, turns on its secondary transmitter. The transferring TCS station, upon noting air vehicle indication of receiving secondary link, commands the air vehicle to transfer and begin taking commands from secondary link. When the air vehicle reports to both stations that it is being commanded by secondary link, the transferring TCS station turns off its primary transmitter. The receiving TCS station, noting the air vehicle report that primary link is lost, turns on its primary transmitter, and commands the air vehicle back to primary link control.
  - Prior to primary link shutdown the receiving TCS station can demonstrate a handoff maneuver, such as a 10-degree turn in one direction, followed by a 10-degree turn in the opposite direction.

5.2.4 Command Override/Abort. The Service component/UAV unit with reporting custodian responsibility for an air vehicle retains command override/abort capability. Exercise of command override/abort should be limited to those occasions when the judgement of competent authority determines air vehicle flight safety is jeopardized. In such cases, immediate notification of the TCS operator from whom control is being assumed and the TCS tasking authority is required.

5.3 Emergency Procedures. For improved operating performance and asset conservation, TCS-controlled multiple air vehicle operations should normally integrate more than one TCS controlling authority/station. When multiple TCS controlling authorities are integrated, the JFC/Service component commander will ensure the existence of emergency procedures between those controlling stations to handle contingency situations when control links or C4I connectivity is interrupted. The following general considerations apply:

5.3.1 Lost Link – Air Vehicle. Lost link instructions are the responsibility of the UAV launch and recovery unit and are part of the mission plan. TCS will be capable of

adjusting those lost link instructions with the concurrence of the launch and recovery station.

Whenever dynamic retasking modifies an air vehicle programmed flight path, the lost link instructions should be reviewed and updated as required. TCS can perform this update by automatically identifying areas not to overfly, minimum safe altitude in the current area of operations, fuel required to return to the launch and recovery station, and furnishing other appropriate warnings as they occur so lost link instructions can be updated immediately when required. This precludes the UAV from flying from an ad hoc position back to the first point of the lost link procedure on a route of flight that could endanger the air vehicle. Updating the lost link instructions prevents the air vehicle from crossing a restricted area, encountering a terrain obstacle that was not planned for, or creating a longer than planned return route that will run the air vehicle out of fuel.

5.3.2 Lost Link - Payload Control. When the TCS operator exercising control loses payload control, notification will be made to the TCS operator exercising air vehicle control at that point. The TCS operator that lost the link will provide the controlling TCS operator with an assessment of the reason for loss of control and whether payload control can be regained. The TCS operator with air vehicle control will attempt to reestablish payload control, and if successful, coordinate a payload handoff back to the operator scheduled to have payload control at that point in the mission. If payload control cannot be regained, the mission commander exercising command override/abort authority will abort the mission and inform the appropriate authority.

5.3.3 Lost Authorized Level of Interaction. When conditions preclude a TCS operating station from performing TCS operations at the level assigned, the appropriate authority will be informed with an estimate of the time to reestablish operating capability at the assigned level. Prompt notification will ensure a reassignment of TCS responsibilities can be accomplished as soon as possible, if required.

5.3.4 Lost C4I Interactivity. When a TCS operating station loses its C4I connectivity, the appropriate intelligence, operations, and C4I representatives on the JFC/Service component/other staff will be informed with an estimate of the time to reestablish connectivity. Prompt notification enables competent authority to determine the necessity of establishing alternate C4I paths for TCS products or coordinating the reassignment of TCS responsibilities within the force.

5.4 Logistics/Maintenance Concepts.

5.4.1 General. TCS logistics and maintenance support will be accomplished in accordance with the Integrated Logistical Support Plan (ILSP) and the maintenance concepts and policies of the individual Services exercising OPCON of TCS assets. TCS shall adhere to DOD regulations and policy governing military standards for logistics,

tools, and Test, Measurement, and Diagnostic Equipment (TMDE). To the maximum extent possible, general purpose test equipment (GPTE) and common tools resident in each Service will be used to perform all corrective and preventative maintenance at all authorized levels of maintenance. Required tools and test equipment not available within Service inventories will be identified as special tools and special purpose test equipment (SPTE) respectively.

5.4.2 Supply Support. Government supply support will be managed by the Naval Inventory Control Point (NAVICP), formerly the Aviation Supply Office (ASO). The NAVICP has been designated program support inventory control point (PSICP) for TCS and related support equipment (SE).

Shipment of TCS and SE spares and repair parts may be commercial on a government bill of lading for CONUS destinations and commercial and government transportation for overseas destinations. The most economical mode of transportation consistent with the priority, required delivery date, and transportability constraints will be used. When deemed necessary by the government, automatic test equipment will be shipped commercially in the continental US (CONUS) by air-ride van or equivalent. Shipments will be made in accordance with DOD directives. TCS hardware will be ruggedized to withstand inter and intra theater movement. Shipping containers will be reusable and enable operators to set up equipment within the established timelines for the UAV system being used.

5.4.3 Maintenance Support. TCS maintenance is accomplished at the organizational, intermediate, and depot levels depending upon the nature of repair required. At the organizational and intermediate levels, Services will support TCS as an integral part of their organic UAV system. Maintenance will be in accordance with each Service's UAV maintenance concepts and procedures. Technical manuals will be in a digital format (joint computer-aided acquisition logistics support [JCALS] compatible) suitable for display on equipment with hard copy printout capability.

- Army - Army will use maintenance practices established for Communication, Intelligence and Electronic Warfare (IEW), Aviation, and Ground Systems.

- Air Force - Air Force maintenance involves maximum use of rapid transportation, minimum repair turn around times, and both intermediate and operating level maintenance at Forward Operating Locations (FOL) and will use the maintenance concepts established in ACCI 21-166, Objective Wing Aircraft Maintenance. 2Exxx Air Force Specialty Code (AFSC) personnel will be responsible for organizational sustainment of TCS equipment.

- Marine Corps - TCS will be supported the same way as a Marine Corps squadron with detachments. TCS and equipment specifically related to the flying of UAVs will be handled in accordance with the Naval Aviation Maintenance Program (NAMP).

- Navy - Navy will utilize the Naval Aviation Maintenance Program (NAMP) and aviation supply system to support TCS.

5.5 Security.

5.5.1 Classification Guidance. The TCS system, including all hardware and software is unclassified. TCS is capable of connecting to classified nodes and C4I systems and internally processing and storing classified imagery and data files. When connected to classified nodes or C4I systems or when classified image processing and storage is accomplished, the system is classified at the level of the connected node or system or the information being processed or stored.

TCS operators, maintenance technicians, and other personnel with access to TCS displays, hardware, or software shall be cleared to the highest classification of the data that TCS is processing and storing.

5.5.2 Physical Security. For baseline land-based, land-mobile, and sea-based TCS configurations, the physical security threat from environmental conditions and enemy attack is inherently no greater than the threat to the force/command/unit at which the TCS is located. However, because TCS serves as a force multiplier to expand the range of UAV command and control possibilities, enemy forces may place a higher priority on targeting units/locations operating UAVs with TCS.

5.5.3 Operational Security (OPSEC). TCS has no specific OPSEC requirements associated with its employment. TCS OPSEC procedures will parallel the requirements for the UAVs and C4I systems with which TCS is interacting.

TCS employs unencrypted data links to interact with the various families of UAVs. These links are susceptible to intercept and jamming. Both active and passive enemy electronic warfare capabilities can be used to provide warning of UAV employment and to target UAVs and TCS control stations. The use of numerous types of camouflage, concealment, and deception (CCD) devices, including multi-spectral netting and radar corner deflectors, can also be effective in reducing the quality and value of the payload product. Depending on the operating environment and hostile electronic combat systems present, the threat to TCS operations could range from negligible to active jamming of the ground station and air vehicle.

5.5.4 Communications Security (COMSEC). To ensure minimum chance of accidental or unauthorized intrusion into the TCS/UAV command and control (C2) link,

software and hardware measures, controlled by the service deploying the UAV, must be available to ensure positive control of the UAV from launch through recovery. To ensure emissions security TCS is compliant with National Security Agency (NSA) standards for collateral level information processing and interfacing to secure networks. TCS also complies with service information protection measures, strategies, and architectures to the level of COMSEC supported by the networks to which TCS is interfaced.

5.6 NATO/Allied Interoperability. TCS can support NATO reconnaissance requirements. Early identification of interoperability considerations will assist in developing the interface standards between TCS, NATO UAVs and, C4I architectures that will be adopted as NATO Standardization Agreements (STANAGS). Data links are the critical interoperability issue. Three standard data links are being considered. The US common data link (CDL) including tactical interoperable ground data link (TIGDL) is being considered as a line-of-sight, point-to-point data link operating in the I or X Band. No data link has yet been prescribed for the UHF band; however, the Hunter data link is a possible choice. The British have committed to developing an omni-directional broadcast data link. Standards for satellite data links must be compliant with commercial standards established by the various international satellite consortiums (intelligence satellite (INTELSAT), Pan-American satellite (PANAMSAT), etc.).

APPENDIX A - TACTICAL CONTROL SYSTEM (TCS) PROGRAM

A.1 Program Management. The TCS Program Manager (PM), Office code: PM-TCS, resides in the Navy Program Executive Office for Cruise Missiles and Joint Unmanned Aerial Vehicles (PEO-CU). The PM is responsible for the day-to-day direction of the TCS program. Matrix support is provided through the Naval Aviation (NAVAIR) Systems Command Naval Air Warfare Center Aircraft Division (NAWCAD), the Naval Surface Warfare Center Dahlgren Division (NSWCDD), the Systems Integration Laboratory (SIL), Army Missile Command (MICOM) and other field activities and support offices.

A.2 TCS Schedule. TCS is being developed as an ACAT II program under a three-phase development process as shown in Figure A-1.
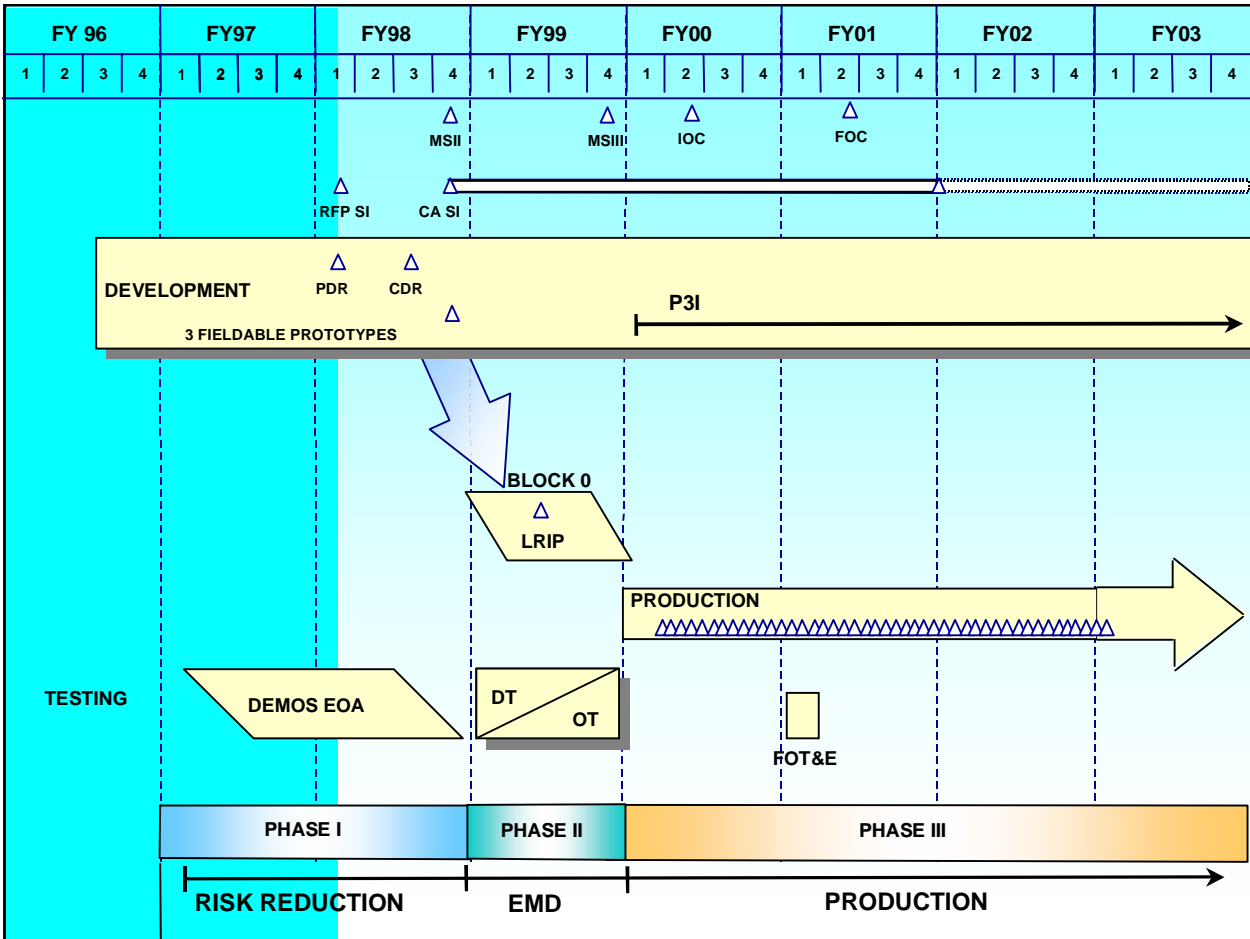
Figure A-1 TCS Schedule

Phase I of the TCS program began in FY 97 and will provide program definition and risk reduction through the use of three fieldable prototypes (1 sea-based & 2 land-based) over a 24-month demonstration period. During this phase TCS common core functions will be interfaced

with Predator and Outrider air vehicles and payloads. System demonstrations will include air vehicle and payload control of Predator and Outrider. The TCS prototypes will also be interfaced with user selected C4I systems such as ASAS, IAS, JMCIS. Lessons learned from TCS demonstrations and employment of TCS in actual joint and Service exercises will be incorporated into the TCS development process and acquisition documentation developed during this phase. Phase I will conclude with a Milestone II decision in fourth quarter FY 98/first quarter FY 99.

Phase II will focus on engineering and manufacturing development (EMD) and the production of six low rate initial production (LRIP) systems to conduct system developmental testing/operational testing (DT/OT). System documentation and software developed under Phase I will be provided as government furnished equipment (GFE)/government furnished installation (GFI) to support DT/OT. During this phase fully scaleable and modular sea and land-based systems will be integrated with existing platform hardware. Final production system hardware and software configurations will be determined. Phase II will conclude with a Milestone III decision in fourth quarter FY 99.

Phase III encompasses production, fielding/deployment and operational support of TCS. At this point TCS will have become the command, control, and data dissemination system for Predator, Outrider, Pioneer and all future TUAV air vehicles and payloads. A firm fixed price contract to produce approximately 30 systems a year will be awarded. Additionally, retrofit of Predator and Outrider systems modified during Phase I or II and validation of remaining C4I interfaces will be accomplished.

A.3 Initial Operational Capability (IOC). IOC will be declared when each Service has completed DT/OT and fielded one production representative TCS and has integrated logistics support (ILS) procurement (training, spares, technical publications, and support equipment) in place. The level of performance necessary to achieve IOC requires one system in a final configuration with operators and maintenance personnel trained and initial spares with interim repair support in place. IOC is planned for the second quarter FY00.

A.4 Full Operational Capability (FOC). FOC will be achieved when all maintenance and repair support, software support, test equipment and spares are in place and TCS systems are effectively employed. FOC is planned for the second quarter FY01.

A.5 Service TCS Force Structure. TCS force structure is based upon individual Service requirements. Air Force TCS force structure will be met by integrating TCS capability into the 12 Predator GCSs by forward-fitting future production systems and backfitting existing systems. Army TCS force structure will support Army requirements at corps, division, brigade, and ACR echelons. Navy TCS force structure will support Navy requirements aboard amphibious ships, surface combatants, aircraft carriers, command ships, and submarines. Marine Corps TCS force structure will support Marine Corps requirements for expeditionary forces, pre-positioning, and war reserve.

Planned TCS force structure is shown in Figure A-2.

SERVICE	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FUTURE	TOTALS
Air Force	1	1						10	12
Army	1	97	32	40	19	39	TBD	309	537
Navy	1	5	6	4	5	4	5	71	101
Marine Corps	1	4	2	2	2	2		4	17
TOTALS	4	107	40	46	26	45	TBD	394	667

Figure A-2 TCS Force Structure

A.6 TCS Demonstration/Exercise Schedule. TCS will meet its developmental objectives through a rigorous schedule of system demonstrations and participation in exercises to validate system functionality and UAV and C4I interfaces. Figure A-3 depicts the planned schedule.
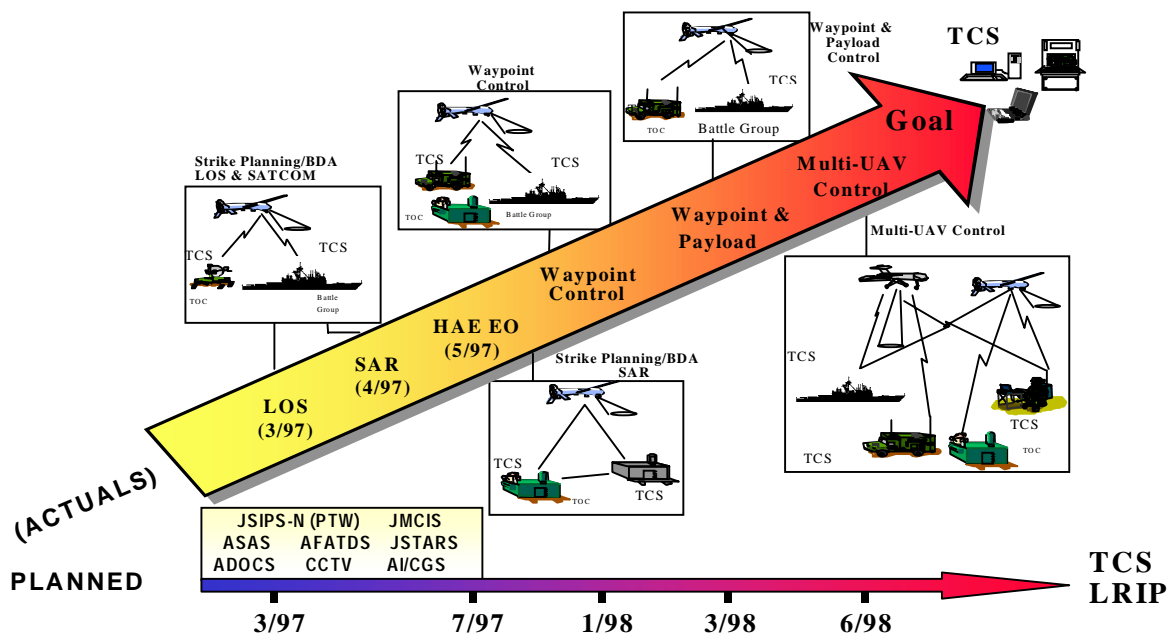
Figure A-3 TCS Developmental Schedule

APPENDIX B – OPERATIONAL CONFIGURATIONS

Specific capabilities of each TCS system will vary according to the hardware configuration based upon the operational requirements of the user. Scaleability of hardware allows individual system tailoring to meet the operator's needs for UAV command and control (LOS or BLOS and single UAV or multiple UAV) and type of imagery processing (EO/IR or SAR).

The configurations contained in the following chart represent the notional capability mixes of Service TCS systems by location at which they are operationally employed:

B.1 AIR FORCE CAPABILITIES.

UNIT/LOCATION UAV TYPE	TCS LEVEL	LOS	BLOS	EO/IR	SAR	MULTIPLE UAV CONTROL	AUTO LAUNCH & RECOVERY
Predator GCS/TCS							
Predator	5	X	X	X	X	X (1)	
AOC/WOC/IES							
HAE	1						
Outrider	1						
Pioneer	1						
Predator	1						
UES							
HAE	2	X	X	X	X		
Outrider	1						
Pioneer	1						
Predator	2	X	X	X	X		

Note: (1) Relief on station (ROS) capability.

B.2 ARMY CAPABILITIES.

UNIT/LOCATION UAV TYPE	TCS LEVEL	LOS	BLOS	EO/IR	SAR	MULTIPLE UAV CONTROL	AUTO LAUNCH & RECOVERY
Outrider shelter							
HAE	1				X		
Outrider	5	X		X		X	X
Predator	4 (1)	X	X	X	X		
TOC							
HAE	1				X		
Outrider	2	X		X		X	
Predator	2	X	X	X	X		

Note: (1) Requires USAF trained and qualified Predator operator.

B. 3 NAVY CAPABILITIES.

UNIT/LOCATION UAV TYPE	TCS LEVEL	LOS	BLOS	EO/IR	SAR	MULTIPLE UAV CONTROL	AUTO LAUNCH & RECOVERY
CV							
HAE	2	X	X	X	X		
Outrider	4	X		X		X	
Pioneer	4	X		X		X	
Predator	4 (1)	X	X	X	X		
LHA/LHD							
HAE	2	X	X	X	X		
Outrider	5	X		X		X	X
Pioneer	4	X		X		X	
Predator	4 (1)	X	X	X	X		
LPD							
HAE	2	X	X	X	X		
Outrider	4	X		X		X	
Pioneer	5	X		X		X	
Predator	4 (1)	X	X	X	X		
LCC							
HAE	2	X	X	X	X		
Outrider	4	X		X		X	
Pioneer	4	X		X		X	
Predator	4 (1)	X	X	X	X		

UNIT/LOCATION UAV TYPE	TCS LEVEL	LOS	BLOS	EO/IR	SAR	MULTIPLE UAV CONTROL	AUTO LAUNCH & RECOVERY
LCC							
HAE	2	X	X	X	X		
Outrider	4	X		X			
Pioneer	4	X		X			
Predator	4 (1)	X	X	X	X		
SSN							
HAE	1						
Outrider	4	X		X			
Pioneer	4	X		X			
Predator	4 (1)	X		X			

Note: (1) Requires USAF trained and qualified Predator operator.

B.4 MARINE CORPS CAPABILITIES.

UNIT/LOCATION UAV TYPE	TCS LEVEL	LOS	BLOS	EO/IR	SAR	MULTIPLE UAV CONTROL	AUTO LAUNCH & RECOVERY
TOC							
HAE	1						
Outrider	5	X		X		X	X
Pioneer	5	X		X		X	X
Predator	4 (1)	X		X			

Note: (1) Requires USAF trained and qualified Predator operator.

APPENDIX C - C4I INTEROPERABILITY

C.1 SERVICE C4I INTERFACES. TCS is capable of interfacing with a wide variety of current joint and Service C4I systems (see figure C-1 below). In addition, TCS architecture, hardware, and software are designed such that all future C4I systems will also be interoperable with TCS. Current TCS capabilities to output imagery and data, however, exceed the exploitation capabilities of some C4I systems with which TCS can interface. As an example, TCS can disseminate EO/IR payload full motion video, but not all C4I systems are able to receive and process full motion video. Accordingly, management of the TCS-C4I interface(s) is critical to ensure optimum utilization of the TCS system.

The TCS-C4I interface involves the exchange of information between the software application running on the TCS core and the software application running on the C4I system. The types of information exchanged include: payload information or sensor products such as EO/IR full motion video and freeze frame imagery, synthetic aperture radar (SAR) imagery, and meta-data such as payload pointing information. The exchange can also include air vehicle state and geoposition data. The information exchange may be uni- or bi-directional. C4I information that can be input to TCS includes mission tasking, maps, and mission planning information such as waypoints, altitudes, weather, and threat information.

The wide variety of Service C4I systems with which TCS can interface is shown in Figure C-1, TCS-C4I Interoperability.
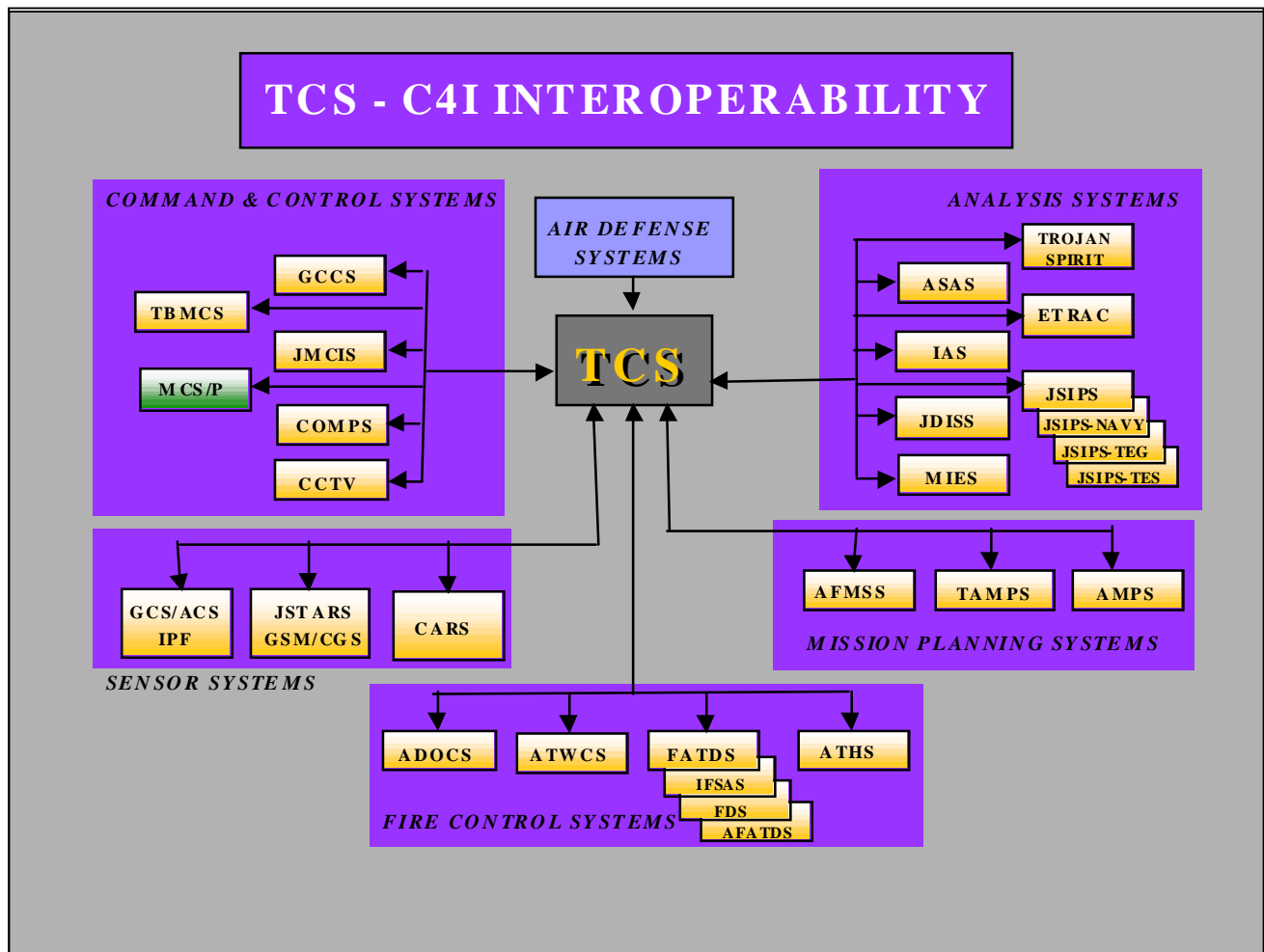
Figure C-1. TCS-C4I Interoperability

The TCS-C4I interface includes two basic forms of information: sensor products, and mission planning and tasking, status query, and mission status reports.

C.1.1 Sensor Products. The following sensor products are available from TCS and can be both received and disseminated by a TCS workstation. TCS imagery products may be verbal or text reports, freeze frame images, short full motion video clips, or continuous, high fidelity, full motion video.

C.1.1.1 Digital Text. Digital text sensor products include messages that contain target descriptive information.

C.1.1.2 Digital Imagery. Digital imagery products include NITF still imagery frames from both EO/IR and SAR payloads and motion picture experts group (MPEG-2) imagery with meta-data encoded in the private data field and meta-data overlays via closed caption. NITF is considered to be the suite of standards specified for the exchange, storage, and transmission of digital imagery.

C.1.1.3 Analog Imagery. Analog imagery is transmitted as National Transmission Standards Committee (NTSC) video in RS-170A formats with meta-data in either closed caption overlays or encoded via closed caption.

C.1.1.4 Analog Voice. TCS can disseminate sensor product information via analog voice over VHF, UHF links, SATCOM, and 2-wire TA-312 land lines. Information consists of either a formatted or unformatted verbal description of imagery.

C.1.1.5 Digital Voice. TCS can disseminate sensor product information via digital voice over VHF, UHF and HF links, SATCOM, and 4-wire land lines including MSE. Information consists of either a formatted or unformatted verbal description of imagery.

C.1.2 Mission Planning and Tasking, Status Queries, and Mission Status Reports. Mission planning and tasking, status queries, and mission status reports are communicated through the use of Variable Message Format (VMF), US Message Text Format (USMTF), and Field Artillery Tactical Data Systems (FATDS) message standards.

C.1.2.1 Mission Tasking and Plans. Mission tasking and planning includes flight route planning, payload/collection planning, communications planning, and dissemination planning. This information is imported and exported through interfaces with Service mission planning systems.

C.1.2.2 Status Queries. Status queries are requests from a C4I system to receive information regarding the UAV or TCS system status or requests for sensor products.

C.1.2.3 Mission Status Reports. Mission status reports are sent to C4I systems and contain information regarding UAV or TCS system status. Status reports may be sent periodically or on demand.

C.1.3 C4I Connectivity. Figure C-2 shows the products TCS provides to various C4I systems and the backbones, intermediate systems or architectures through which TCS connects to disseminate those products.

C4I SYSTEM	PRODUCT(S) FROM TCS (1)	BACKBONE, INTERMEDIATE SYSTEM/ARCHITECTURES (2)
AFATDS	Tactical (TAC) messages	SINGCARS, wireline, MSE
ASAS	TAC messages, still, video	MSE, Army tactical local area network (LAN), SINGCARS
ATHS	????	????
ATWCS	Still	LAN
CARS (DCGS)	Still	Secret Internet protocol router network (SIPRNET) (5D, IPL)
CCTV	Video	RG-59 cable-NTSC; collocated
COMPASS	TAC messages (mission planning data)	LAN
ETRAC	Still	Point-to-point LAN, if collocated (IPL)
GUARDRAIL ACS/IPF	Signals intelligence (SIGINT)	????
IAS	????	????
JDISS (GCCS)	Still	SIPRNET
JMCIS	Video, still, TAC messages	LAN
JSIPS (DCGS)	Still	LAN (5D, IPL)
JSIPS-N	Still	LAN (IPL)
JSTARS GSM/CDS	TAC messages, video, still, SAR waterfall display	LAN-assume collocated with TOC, RG-59 for video
MIES	????	????
Mission planners AFMSS/TAMPS/AMPS	TAC messages	SIPRNET
TBMCS (CIS, WCCS, CTAPS, etc.) and other AOC systems	Video, still, TAC messages	SIPRNET
TEG	Still	LAN (IPL)
TES	????	???? (IPL)
TROJAN SPIRIT II	Imagery (integrated with other systems)	LAN-assume collocated

Figure C-2. C4I Connectivity

Notes: (1) Video, still image (NITF, others), text, TAC messages
(2) SIPRNET, non-secure Internet protocol router network (NIPRNET), JWICS, GBS, MSE, bent pipe (5D, IPL, another TCS)

C.2 COMMUNICATIONS INTERFACES. TCS is interoperable with a wide range of communications media and can interface with existing and future tactical communications networks and systems. TCS can be interfaced to standard DOD deployable (tactical) VHF and UHF line of sight, UHF demand assignment multiple access (DAMA) SATCOM, and HF radios, MSE, and military and commercial satellite communications.

       C.2.1 Communications Media. Figure C-3 contains a partial list of current communications equipment with which TCS can interface. Data rates shown vary depending on the distance and specific application.

COMMUNICATIONS INTERFACE	INTERFACE EQUIPMENT (1)	SENSOR PRODUCT/ INFORMATION TYPE	DATA RATE (KB/S) (2)	ENCRYPTION EQUIPMENT
VHF radio	AN/VRC-89	Analog voice, digital voice, message, & image	16	KY-57
UHF radio	LST-5, AN/PSC-3, AN/CSZ-4A	Analog voice, digital voice, message, & data	16	KY-57/58, KYV-5, KG-84
HF radio	AN/GRC-26D	Analog voice, digital voice, message, & data		KG-84
SATCOM	LST-5, AN/PSC-3, AN/CSZ-4A	Analog voice, digital voice, message, & data	16	KY-57/58, KYV-5, KG-84
LAN	DTE, DCE	Digital data, imagery, & video	100	
RG-59	Cameras, monitors	Analog video	NA	NA
Serial (RS-232) (3)	DTE, DCE	Digital data & imagery	32	KG-84, KY-57, KY-68
Serial (RS-422)	DTE, DCE	Digital data, imagery, & video	100	KG-84

4 wire (includes MSE)	TA-954, KY-68	Digital voice & data	16	KY-68

Figure C-3. Communications Media

Notes: (1) Partial list of currently fielded equipment. Not all models or types are listed.
(2) Data rates vary depending on distance and specific application.
(3) Digital video, serial, and 2 and 4 wire communications media are required to interoperate with designated C4I systems.

C.2.2 TCS Protocols. TCS communications protocols involve the use of messages and key data elements.

C.2.2.1 Messages. The following types of messages are compatible with TCS:

- Variable Message Format (VMF). VMF is the approved data exchange standard for information transfer between systems requiring variable bit-oriented messages. TCS can transmit and receive VMF messages.

- US Message Text Format (USMTF). USMTF messages are fixed format, character-oriented messages that are man-readable and machine-processable. TCS can transmit and receive USMTF messages.

- Field Artillery Tactical Data Messages (FATDS). TCS is capable of transmitting and receiving FATDS TACFIRE messages.

- Threat Information Messages. TCS is capable of transmitting and receiving formatted and unformatted threat information messages.

- Weather Information Messages. TCS is capable of transmitting and receiving weather information messages.

C.2.2.2 Data Elements. The following data elements are those data representative of acceptable TCS input (for mission planning, status query) or TCS output (mission monitoring, status reporting).

- Common data elements. Mission number, mission date and air vehicle tail numbers are common to all UAV mission related message files transmitted from or to TCS.

- Flight route data elements. These elements describe the mission plan of the UAV, both as input for mission planning and dynamic retasking

C-6

purposes, and output for monitoring of mission status. Typical information includes the common data elements, time of update, latitude/longitude, altitude in feet above mean sea level (msl), and true heading in degrees.

- Collection tasking elements. Collection tasking elements are used to create a data collection plan for upload to the air vehicle.

- Communications data elements. These elements describe the communications configuration.

- Threat information data elements. The elements are used to automatically or manually update a threat.

- Weather information data elements. Elements that compose the weather information message.

- Imagery data elements. These elements describe the footprint of an image.

APPENDIX D - INTELLIGENCE OPERATIONS

To be provided with Version 2.0.

APPENDIX E - TRAINING/QUALIFICATION/CURRENCY STANDARDS

E.1 TCS Training. TCS specific training and qualification is required for both TCS operators and maintenance technicians.

TCS training supports the five levels of TCS interaction with both existing and future UAV systems. Training accommodates both single-UAV and multiple-UAV operations and is constructed in modules, scaleable to the level of interaction achievable by the supported TCS configuration or operator qualification. Courseware is designed such that it can incorporate new UAVs and capabilities, when available.

E.2 TCS Training Architecture and Design. Training software leverages the core HCI enabling UAV operators trained and qualified in one UAV system to control different types of UAVs or payloads with minimal additional TCS training. The software is portable and exportable to the field. It performs either as an embedded or add-on interactive capability. TCS training software is compatible with external simulation sources.

TCS provides the capability to train and qualify personnel, and maintain proficiency in the operation of the TCS system, perform TCS UAV control functions, and conduct on-line system troubleshooting. This training capability is alterable without affecting the configuration of the operational software. This capability provides TCS operators and maintenance technicians with embedded or add-on self-paced interactive courseware that duplicates UAV flight performance characteristics, capabilities, and limitations.

The training system does not accommodate concurrent training operations with the execution of actual missions, however, the processing of training messages, if identified as training messages, can be accomplished concurrently with actual mission communications message processing. TCS operator and maintenance technician training actions and retrievable TCS and UAV parameters are recorded to measure performance and for self-assessment and performance enhancement.

E.3 Training Implementation. TCS training implementation is a Service responsibility. Training will be balanced between institutional, new equipment, and unit training. Initial training efforts will focus on new equipment training and developing an instructor cadre while maintaining operational capability until institutions and field units can stand-alone. Sustainment training will encompass training at the institutional level and in-service training at the unit level. Training will initially emphasize training of individual Service training teams and key personnel who will integrate TCS core training into existing Service/UAV system training curricula. Once institutionalized within Service/system curricula, training emphasis will shift to instructors and operators to support the fielded systems and then finally provide advanced training for designated personnel.

E.4 Training Curriculum. Three training courses will be provided. All courses will be developed in modular format that will allow grouping and mixing and matching of functional areas and individual lessons to support differences in existing training syllabi.

    E.4.1 TCS Core Course: The TCS core course is designed to support initial qualification training at institutional bases. It supports Levels 1 – 4 for single UAV operations and consists of training in the following specific areas:

- Initialization/Shutdown
  Set-up
  Interactivity level
  Map display
  Built in test (BIT)

- Mission Planning
  Air vehicle route
  Payload
  Communications

- Mission Control & Monitor
  Air vehicle
  Payload
  Data link

- Payload Processing
  Image process
  Image display
  Image exploitation

- C4I Interface
  Communications
  Tactical communications
  Data dissemination

- Fault Detection/Isolation
  BIT
  Troubleshooting

    E.4.2 TCS Advanced Course. The TCS advanced course is designed to support qualification for Level 3 –5 operations. It is based on Service criteria for their specific air vehicles.

E.4.3 TCS Maintenance Course. Maintenance training courses, generic for all TCS configurations, are available for each level of maintenance. Maintenance personnel/technicians require specific training and qualification for the level of maintenance to be performed (e.g., operational, intermediate, or depot). Any host UAV system maintenance procedures requiring modification as a result of TCS integration, are the responsibilities of the respective Service UAV Program Manager.

E.5 Service Training. Service UAV operator and maintenance technician training and qualification will be conducted in accordance with formal requirements as prescribed by Service training commands. Service policy and doctrine will dictate air vehicle and payload operator currency standards.

E.5.1 Air Force. Air Force requires MAE UAV (Predator) air vehicle operators to be Rated Officers. Imagery payload operators require an AFSC of 1N1. Communications electronics maintenance technicians require a 2Axxx AFSC and system administrators require a 3C0X1 AFSC.

Currency standards (Air Force Regulation (AFR) 51-4):
- Payload control - *requires Service input*
- Air vehicle control:
  - Less than 45 days - one takeoff and one landing
  - Between 46 and 90 days - one takeoff and one landing under the supervision of an instructor pilot
  - In excess of 90 days - requires requalification
- Air vehicle launch and recovery:
  - Less than 45 days - one takeoff and one landing
  - Between 46 and 90 days - one takeoff and one landing under the supervision of an instructor pilot
  - In excess of 90 days - requires requalification

E.5.2 Army. Army requires TUAV (Outrider/Hunter) air vehicle operators, including those conducting payload operations and limited data exploitation, to have a Military Operator Specialty (MOS) code of 96U (UAV operator). Technicians require a 33R MOS. Mechanics currently require a 52D MOS.

Training requirements:
- Operator training – approximately 23 weeks including 26 simulator flights, five vehicle operator (VO) 1.5 hour flights and a check flight, five payload operator (PO) 1.5 hour flights and a check flight, two preflights, launches and recoveries, and 3.5 hours of local flight training.

- External pilot (EP) – approximately 151 hours including seven hours of classroom instruction, 114 hours of scale model training, and 30 hours of air vehicle day training and 5 night launches and recoveries.

Qualification requirements:
- Readiness Level 3 (Qualification/Refresher Training) – for operators undergoing qualification or refresher training.
- Readiness Level 2 (Mission Training) – for operators developing proficiency in mission-related tasks.
- Readiness Level 1 (Continuation Training) – for operators who are mission ready.

Currency standards (Army Training Manual – ATM TC 34-212):
- Payload control:
  - Less than 90 days – one local flight of 30 minutes duration
- Air vehicle control:
  - Less than 90 days – one local flight of 30 minutes duration to include preflight, launch, traffic pattern, emergencies and landing
- Air vehicle launch and recovery (EP):
  - Day
    - Less than 45 days – one rolling takeoff, one full stop landing, 30 minutes of local flight time including touch and go landings and simulated emergencies, and passing of bold face action emergency procedures written exam.
  - Night
    - Less than 90 days – one rolling takeoff, one full stop landing, 30 minutes of local flight time including touch and go landings and simulated emergencies, and runway set-up for night operations. Day currency requirements must be met within 5 days prior to night flight operations.
- Semi-annual hour requirements:
  - EP – 12 hours
  - VO – 10 hours
  - PO – 10 hours

Note: Operators qualified as both VO and PO require 5 hours of VO time and 5 hours of PO time.

E.5.3 Navy. Navy requires TUAV (Pioneer) air vehicle and payload operators to have a Navy Enlisted Classification (NEC) code of 8362, 8364, or 8365. Mechanics and technicians require NEC codes of 8361 and 8363, respectively.

Currency standards *(Navy xyz manual)*:
- Payload control:
  - Less than 90 days – one flight
  - Greater than 90 days – one refresher flight under the supervision of an instructor pilot
- Air vehicle control:
  - Less than 90 days – one flight
  - Greater than 90 days – one refresher flight under the supervision of an instructor pilot
- Air vehicle launch and recovery:
  - Shorebased operations –
    - Less than 45 days – one flight with one takeoff, five touch and go landings, and one recovery
    - Greater than 45 days – one training device flight under the supervision of a qualified external pilot
  - Shipboard operations –
    - Less than 45 days – one flight with one takeoff, five approaches, and one recovery
    - Greater than 45 days – one training device flight under the supervision of a qualified external pilot
  - Night currency –
    - Less than 60 days – one night flight within 5 days of a day flight

E.5.4 Marine Corps. Marine Corps requires TUAV (Pioneer) operators to have a 7314 MOS (for internal pilots and payload operators) and a 7316 MOS (for external pilots). Technicians and mechanics require 6314 and 6014 MOSs, respectively.

Currency standards: *JUAVTOPS Manual*

- Internal pilots, mission commanders, and payload operators that have not operated a TUAV in their respective positions within the last 90 days require a refresher flight under the supervision of a certified instructor.

- External pilot currency is based on the following chart. Requirements must be met within a 60-day period. To regain currency, a recurrency flight with an EP instructor is required consisting of one takeoff, five touch and goes or low approaches, and one landing. Before the recurrency flight, one hour of training device time with an EP instructor is required.

EP Currency	Takeoff/Launch	Touch & go (T&G) or low approach (LA)	Landings	Training Device
Shore day	2	10	2	6 hours
Shore night	1	5	1	2 hours
Sea day	2	15	2	6 hours
Sea night	1	5	1	2 hours

- External pilots that have not flown in one week require a 1 hour training device flight prior to an actual TUAV flight (note: a day flight must be flown within 5 days prior to a night flight).

- Each crew position is required to complete a written examination and flight evaluation annually.

- Unit commanders are authorized to waive, in writing, minimum flight and training requirements where recent experience and knowledge of UAV operations warrant.

APPENDIX F – REFERENCES

The documents and publications listed below were used in the preparation of this Concept of Operations or provide amplifying or more detailed information regarding TCS.

F.1 DOD DOCUMENTS.

DARO UAV Annual Report, 6 Nov 97

DUSD (A & T) Memorandum dated 21 Dec 95, Initiating the TUAV ACTD

ASN (RDA) Memorandum dated 12 Sep 1997, Tactical Control System, Acquisition Category II Designation

F.2 JCS DOCUMENTS.

JROCM 011-97 dated 3 Feb 97, Unmanned Aerial Vehicle (UAV) Tactical Control System (TCS) Operational Requirements Document (ORD)

JROCM 010-96 dated 12 Feb 96, Predator Unmanned Aerial Vehicle

JROCM 135-95 dated 31 Oct 95, Tactical Unmanned Aerial Vehicle

JROCM 003-90 dated 5 Jan 90, Mission Needs Statements for Close Range Reconnaissance, Surveillance, and Target Acquisition (RSTA) Capability and Long Endurance Reconnaissance, Surveillance, and Target Acquisition (RSTA) Capability

Joint Pub 2-0, Doctrine for Intelligence Support to Joint Operations, 5 May 95

Joint Pub 2-01, Joint Intelligence Support to Military Operations, 20 Nov 96

Joint Pub 3-01.4, JTTP for Suppression of Enemy Air Defenses, 25 Jul 95

Joint Pub 3-01.5, Joint Doctrine for Theater Missile Defense, 22 Feb 96

Joint Pub 3-02, Joint Doctrine for Amphibious Operations, 8 Oct 92

Joint Pub 3-07.4, Joint Counterdrug Operations, 9 Aug 94

Joint Pub 3-50.2, Doctrine for Joint Combat Search and Rescue, 26 Jan 96

Joint Pub 3-52, Doctrine for Joint Airspace Control in a Combat Zone, 22 Jul 95

Joint Pub 3-55, Doctrine for Reconnaissance, Surveillance, and Target Acquisition Support for Joint Operations, 14 Apr 93

Joint Pub 3-55.1, JTTP for Unmanned Aerial Vehicles, 27 Aug 93

Joint Pub 3-56.1, Command and Control for Joint Air Operations, 14 Nov 94

CJCSI 3250.1, Sensitive Reconnaissance Operations, Apr 96

CJCSM 3500.4A, Universal Joint Task List, 13 Sep 96

F.3 PEO-CU DOCUMENTS.

TCS Joint Interoperability Interface 2, TCS to Service Command, Control, Communications, and Intelligence Systems, Version 1.0, 9 May 97

TCS System/Subsystem Specification (SSS), Version 1.0, 30 Jun 97

UAV TCS Program Management Plan (PMP), Version 4.1, 6 Aug 1997

TCS System/Subsystem Design Description (SSDD), Preliminary Draft, 8 Aug 97

Configuration Management (CM) Plan for the UAV Tactical Control System (TCS) (Draft), 10 Oct 97

TCS Software Requirements Specification (SRS), Version 1.1, 29 Oct 97

F.4 SERVICE DOCUMENTS.

Air Combat Command CONOPS for Endurance UAVs, Version 2, 3 Dec 96

Army Training Manual ATM TC 34-212

Marine Corps JUAVTOPS

Navy _____

F.5 MISCELLANEOUS DOCUMENTS.

USACOM HAE ACTD Joint CONOPS, Version 3.0, 15 Mar 96

APPENDIX G – GLOSSARY

PART I - ABBREVIATIONS and ACRONYMS

ACA	airspace control authority
ACAT	acquisition category
ACE	Aviation Combat Element (MAGTF)
ACOM	United States Atlantic Command
ACR	Armored Calvary Regiment
ACS	Aerial Common Sensor
ACTD	advanced concept technology demonstration
ADCON	administrative control
ADOCS	Automated Deep Operations Coordination System
ADT	air vehicle data terminal
AEF	Air Expeditionary Force
AFATDS	Advanced Field Artillery Tactical Data System
AFMSS	Air Force Mission Support System
AMPS	Army Mission Planning System
AO	area of operation
AOC	Air Operations Center
AOR	area of responsibility
ASAS	All Source Analysis System
ASO	Aviation Supply Office
ATF	amphibious task force
ATHS	Automated Target Handoff System
ATM	Army Training Manual
ATO	Air Tasking Order
ATWCS	Advanced Tomahawk Weapons Control System
AV	air vehicle
AVO	air vehicle operator
AVSI	air vehicle standard interface

BDA	battle damage assessment
BIT	built in test
BLOS	beyond line-of-sight

C2	command and control
C4I	command, control, communications, computers and intelligence
CARS	Contingency Airborne Reconnaissance System
CAS	close air support
CBT	Computer-based training

CCD	camouflage, concealment, and deception
CCTV	closed circuit TV
CDL	common data link
CIG/SS	Common Imagery Ground/Surface Station
CINC	Commander in Chief
CGS	common ground segment, common ground station
CJCS	Chairman of the Joint Chiefs of Staff
CLF	Commander, Landing Force
COCOM	combatant command
COE	Common Operating Environment
COMPASS	Common Operational Modeling, Planning, and Simulation System
COMSEC	communications security
CONOPS	concept of operations
CONUS	continental United States
CPU	central processing unit
CV/CV(N)	aircraft carrier/aircraft carrier (nuclear)

DAMA	demand assigned multiple access
DARO	Defense Airborne Reconnaissance Office
DARS	Daily Aerial Reconnaissance Syndicate
DCGS	Distributed Common Ground System
DCM	data link control module
DDE	Direct Dissemination Element (HAE)
DEMPC	data exploitation, mission planning, and communications (Predator GCS)
DII	Defense Information Infrastructure
DISA	Defense Information Systems Agency
DIWS (A)	digital imagery workstation (afloat)
DOD	Department of Defense
DT	developmental testing
DUSD (A & T)	Deputy Under Secretary of Defense (Acquisition and Technology)

EEI	essential elements of information
EMD	engineering, manufacturing, development
EO	electro-optical
EP	external pilot
ETRAC	Enhanced Tactical Radar Correlator
EUAV	endurance UAV
EW	electronic warfare

FAA	Federal Aviation Administration
FATDS	Field Artillery Tactical Data System

FOC	full operational capability
FOL	forward operating location
FTP	file transfer protocol

GBS	Global Broadcast Service
GCCS	Global Command and Control System
GCE	Ground Combat Element
GCS	Guardrail Common Sensor/ground control station
GDT	ground data terminal
GFE	government furnished equipment
GFI	government furnished installation
GPS	Global Positioning System
GPTE	general purpose test equipment
GSM	Ground Station Module (JSTARS)

HAE	high altitude endurance
HCI	human computer interface
HF	high frequency
HMMWV	high mobility multi-purpose wheeled vehicle
HUD	heads-up display

IAS	Imagery Analysis System
ICAO	International Civil Aviation Organization
IDT	integrated data terminal
IES	Imagery Exploitation System
IEW	intelligence and electronic warfare
ILSP	Integrated Logistics Support Plan
IMINT	imagery intelligence
INTELSAT	intelligence satellite
IOC	initial operational capability
IP	internal pilot, Internet protocol
IPB	intelligence preparation of the battlefield
IPF	Integrated Processing Facility
IPL	imagery product list
IR	infrared
ISR	intelligence, surveillance, reconnaissance

J2	Intelligence Officer
J3	Operations Officer
JCALS	joint computer-aided acquisition logistics support

JCS	Joint Chiefs of Staff
JDISS	Joint Deployable Intelligence Support System
JFACC	Joint Force Air Component Commander
JFC	Joint Force Commander
JIC	Joint Intelligence Center
JII	joint integration interface
JMCIS	Joint Maritime Command Information System
JPEG	joint photographic experts group
JPO	Joint Project Office
JORD	joint operational requirements document
JROC	Joint Requirements Oversight Council
JROCM	JROC Memorandum
JSIPS	Joint Service Imagery Processing System
JSIPS-N	Joint Service Imagery Processing System-Navy
JSTARS	Joint Surveillance, Target Attack Radar System
JTA	Joint Technical Architecture
JTF	Joint Task Force
JUAVTOPS	Joint UAV Training Operating Procedures
JWICS	Joint Worldwide Intelligence Communications System
JWPG	Joint Warfighter Planning Group

Kb	kilobyte
km	kilometer
kW	kilowatt

LA	low approach
LAN	local area network
LB	land-based
LCC	amphibious command ship
LHA	amphibious assault ship
LHD	amphibious assault ship (internal dock)
LPD	amphibious transport dock ship
LNO	liaison officer
LO	low observable
LOS	line-of-sight
LRIP	low rate initial production

MAE	medium altitude endurance
MAGTF	Marine Air-Ground Task Force
Mb	megabyte
MCE	Mission Control Element (HAE UAV)

MC&G	mapping, charting, and geodesy
MICOM	Missile Command (Army)
MIES	Modernized Imagery Exploitation System
MM	mobile unit
MNS	mission needs statement
MOOTW	military operations other than war
MOS	military operations specialty
MPEG	motion pictures experts group
MPO	mission payload operator
MSE	Mobile Subscriber Equipment
msl	mean sea level

NAMP	Naval Aviation Maintenance Plan
NATO	North Atlantic Treaty Organization
NAVAIR	Naval Air Systems Command
NAVICP	Naval Inventory Control Point
NAWCAD	Naval Air Warfare Center Aircraft Division
NEC	Navy enlisted classification
NEO	non-combatant evacuation operation
NFS	network file server
NIMA	National Imagery & Mapping Agency
NIPRNET	non-secure Internet protocol router network
NITF	National Image Transmission Format
nm	nautical mile
NRT	non real-time
NSA	National Security Agency
NSFS	naval surface fire support
NSWCDD	Naval Surface Warfare Center Dahlgren Division
NTSC	National Transmission Standards Committee

ODCM	Outrider DCM
OPCON	operational control
OPLAN	operations plan
OPORD	operations order
OPSEC	operational security
OT	operational testing

PANAMSAT	Pan-American satellite
PDCM	Predator DCM
PDU	Power Distribution Unit
PED	processing, exploitation, dissemination

PEO-CU	Program Executive Officer-Cruise Missiles and Unmanned Aerial Vehicles
PiDCM	Pioneer DCM
PM	preventative maintenance, program manager
PO	payload operator
PSICP	program support inventory control point
PTW	Precision Targeting Workstation
RAID	Redundant Array of Inexpensive Disks
RFI	request for information
ROS	relief on station
RSTA	reconnaissance, surveillance, and target acquisition
RTP	real time processor
SAR	synthetic aperture radar
SATCOM	satellite communications
SB	sea-based
SE	support equipment
SECDEF	Secretary of Defense
SIGINT	signals intelligence
SIL	System Integration Laboratory
SINCGARS	Single Channel Ground and Airborne Radio System
SIPRNET	secret Internet protocol router network
SMTP	simple mail transfer protocol
SOC	Special Operations Command
SOF	special operations force
SPTE	special purpose test equipment
SRO	sensitive reconnaissance operations
SSN	attack submarine (nuclear)
STANAG	standardization agreement (NATO)
T&G	touch and go landing
TAC	tactical message
TAMPS	Tactical Aircraft Mission Planning System
TBD	to be determined
TBMCS	Theater Battle Management Core System
TBMD	theater ballistic missile defense
TCDL	tactical CDL
TCP	transmission control protocol
TCS	Tactical Control System
TEG	Tactical Exploitation Group
TES	Tactical Exploitation System

TIGDL	tactical interoperable ground data link
TMDE	test, measurement, and diagnostic equipment
TOC	tactical operations center
TTO	TCS Tasking Order
TUAV	tactical UAV

UAV	unmanned aerial vehicle
UES	UAV Exploitation System
UHF	ultra high frequency
UIM	User Interface Module
UPS	uninterruptable power supply
USACOM	United States Atlantic Command
UCARS	UAV Common Automated Recovery System
UN	United Nations
US	United States
USCINCACOM	Commander in Chief, United States Atlantic Command
USMTF	US message text format

VCR	video cassette recorder
VHF	very high frequency
VME	Versa module Eurocard
VMF	variable message format
VO	vehicle operator

WOC	wing operations center

PART II – TERMS AND DEFINITIONS

commonality – a quality that applies to materiel or systems: a. possessing like and interchangeable characteristics enabling each to be utilized, or operated and maintained, by personnel trained on the others without additional specialized training. b. having interchangeable repair parts and/or components. c. applying to consumable items interchangeably equivalent without adjustment. For TCS: use of the same hardware, software or user display.

compatibility –Capability of two or more items or components of equipment or material to exist or function in the same system or environment without mutual interference.

Dark Star UAV – low observable (LO) HAE unmanned aerial vehicle capable of greater than 8 hours endurance at altitudes in excess of 45,000 feet at an operating radius of 500 nm; currently under development as an ACTD. Also known as Tier III- UAV. Dark Star is capable of fully automatic flight. Dark Star is intended to provide critical imagery intelligence from highly defended areas. Air vehicle performance and payload capacity are traded for survivability features against air defenses, such as the use of low observable technology to minimize the air vehicles' radar return. The Dark Star payload may be either SAR or EO. The air vehicle is self-deployable over intermediate ranges.

endurance UAV – unmanned aerial vehicle designed to support JTF commanders and theater/national C2 nodes with long-range, long-dwell, near-real time theater/tactical intelligence via deep penetration/wide-area surveillance. Endurance UAVs are fully autonomous, dynamically retaskable, medium to high altitude, long endurance, survivable UAVs that can gather and provide near real time, high quality IMINT and SIGINT of areas where enemy defense have not been adequately suppressed, in heavily defended areas, in open ocean environments, and in contaminated environments.

Global Hawk UAV – conventional HAE unmanned aerial vehicle capable of 20 hours endurance at 60,000+ feet altitude at an operating radius of 3,000 nm; currently under development as an ACTD. Also known as Tier II+ UAV. Global Hawk is capable of fully automatic flight. Global Hawk will be directly deployable from well outside the theater of operations, followed by extended on-station time in low- to moderate-risk environments to look into high-threat areas to provide both wide-area and spot imagery. Global Hawk can carry EO, IR, and SAR sensors concurrently and operate SAR and either EO or IR payloads simultaneously. Survivability derives from the very high operating altitude and self-defense measures.

HAE UAV – high altitude endurance unmanned aerial vehicle. The HAE UAV family includes Global Hawk and Dark Star UAVs that are under development as an ACTD.

Hunter UAV – a joint tactical UAV originally developed to provide both ground and maritime forces with near-real time IMINT within a 200 km direct radius of action, extendable to 300+ km by using another Hunter as an airborne relay. Capable of operating from unimproved airstrips to

support ground tactical force commanders. Operates at altitudes up to 15,000 feet and at ranges greater than 100 nm.

integration – two or more systems working together toward a common or mutually supportive mission.

interaction – a one or two way exchange of data among two or more systems/sub-systems.

interface – a point common to two or more similar or dissimilar C2 systems, sub-systems, or other entities at which necessary information flow takes place. Compliant with necessary protocols and formats.

interoperability – the condition achieved among communications-electronics systems or items of communications-electronics equipment when information or services can be exchanged directly and satisfactorily between them and/or their users. When multiple air vehicles are used in a joint operation with the same software to control the air vehicles and payloads, and disseminate and exploit the data.

MAE UAV – medium altitude endurance unmanned aerial vehicle. The MAE UAV family includes the Predator UAV currently in procurement and being operated by the Air Force.

modularity – the use of sub-systems or components from one system to function properly as part of another system. The interface at the sub-system level is sufficiently defined.

non-real time processing – non-flight critical processing accomplished within the host system software including interface to C4I system(s). Pertaining to the timeliness of data or information that has been delayed by the time required for electronic communication and automatic data processing. This implies that there are no significant delays.

Outrider UAV – a TUAV program developed as an ACTD to support tactical commanders with near-real time IMINT at ranges beyond 200 km and with on-station endurance of greater than four hours. Designed to replace the Hunter and maneuver UAV programs by providing RSTA and combat assessment (CA) at Army brigade/battalion, Navy task force and Marine Corps regimental/battalion levels.

Pioneer UAV – DOD's first operational UAV system. Developed as an interim capability to provide IMINT for tactical commanders on land and at sea. Operates at altitudes up to 15,000 feet and at ranges greater than 100 nm.

Predator UAV – MAE UAV designed to provide long-range/dwell, near real-time tactical intelligence, RSTA, and BDA with EO/IR and high-resolution SAR IMINT. Also known as Tier II UAV. Operates at altitudes up to 25,000 feet at a radius of up to 500 nm.

real-time processing – AV command and control info including antenna positioning and AV video receipt and processing. Pertaining to the timeliness of data or information that has been delayed only by the time required for electronic communication. This implies that there are no noticeable delays.

scaleability – the characteristic that enables system size and capability to be tailored dependent on user needs.

tactical UAV – unmanned aerial vehicle designed to support Army battalions, brigades, and light divisions, Marine Corps regiments, and deployed Navy units with near-real time RSTA, and BDA.

TCS operator – an individual specifically trained in the operation of the TCS system who is functioning at a TCS workstation.

TCS user – an individual not necessarily specifically trained in the operation of the TCS system who is receiving and using TCS-derived imagery products either directly from a TCS workstation or through a C4I system.

waypoint control – semi-autonomous or man-in-the-loop method of air vehicle control involving the use of defined points (latitude/longitude/altitude) to cause the UAV (air vehicle, sensor(s), or onboard systems) to accomplish certain actions.